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目次

水稻品種（系）對稻熱病抵抗性反應之研究…………………………… 陳隆澤……1
稻米粒品質之改良　Ⅱ.米粒膠體硬度及顆粒澱粉含量之遺傳…郭益全 謝順景……14
蘆筍莖頂培養之研究……………………… 賴本智 陳良築 許淼淼 蔡新聲……23
檬果腋花穗之誘引 ………………………………………………… 許仁宏……32
荔枝大核與小核種果實性狀變異之研究（英文）……………………… 顏昌瑞……39
季節變異對茭白花性表現之影響（英文） ………………………… 劉政道……50
臺灣大豆銹病菌生理小種之鑑定（英文） ………………………… 葉忠川……69
唐昌蒲球莖蟎（*Rhizoglyphus robini*）之為害與其防治（英文）…… 王清玲……75
本省柑橘園土壤之酸性化與其酸性來源 …………………………… 黄文良……83
水稻聯合收穫機用於收穫高粱之研究試驗………………… 顏欽崇 楊清祥……92

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水稻品種（系）對稻熱病抵抗性反應之研究[1]

陳 隆 澤[2]

摘要 測定國內外抗病品種（系）對本省主要稻熱病菌生理小種之反應，期以選得高度穩定抗病種源做爲抗病育種之材料，並探討水稻品種（系）對葉及穗稻熱病抵抗性之相關以及期作、接種源等與抗病性之關係，以供抗病育種之參考。玆將試驗結果摘述如下：

1.參試20個品種（系）以人工接種本省主要流行稻熱病菌生理小種結果顯示對六個小種均表現抗病的有12個品種（系），惟除臺南6號及臺東29號外均爲秈稻。一般抗葉稻熱病之品種（系）亦對穗稻熱病具有抵抗性，但有例外。

2.統一病圃檢定結果與人工接種結果頗相符合，能抵抗多數小種的品種（系）在病圃亦多表現高度抗病性。CIAT-ICA 5, IR1416-123-5-8, IR1905-pp11-29-4-61, IR3239-5-160-3, IR4547-2-1-2, IR5533-pp834-1 及 IR9660-00948-1 等品系均具有高度抗病性是爲抗病育種之最佳材料。

3.水稻品種在七十年第一、二期作對同一接種源之反應均極一致，無論秈、稉稻均然。

4.臺南5號及臺農67號在第一期作低溫時較易感病，但嘉農秈8號及11號則在第二期作高溫下較易感病，尤以穗稻熱病在期作間差異更顯著。

稻熱病爲本省稻作最主要病害之一，尤其第一期作常常發生猖獗而導致嚴重的損失，根據農林廳稻作主要病蟲害發生面積調查資料，本省過去數十年中，每年一期作發生稻熱病的稻田均佔稻作栽培面積的十分之一以上[14]，估計稻谷損失每年約達總生產量之5％之鉅[18,35]，可見其對本省稻作生產威脅之大。使用藥劑防治非但價錢昂貴，效果短暫，而且往往不能把握最適當的施藥時期，不易達到澈底防治效果，徒增生產成本，還易使病原菌產生抗藥性，甚且造成環境汚染，破壞自然生態。因此栽植抗病品種，一直被認爲是防治稻熱病最經濟有效的理想方法[17,18,26,35]。

本省抗稻熱病育種始自1950年[35]，三十多年來雖先後育成不少如嘉農242號，臺中181號、186號，臺南6號，臺農62號，臺東29號及高雄141號等抗病品種，但這些品種僅能抗病於一時或一地，推廣後不久即逐漸失去其抗病性[3,12,13,1718,40]，國外亦有許多相似的報導[26,31,32,41]。究其原因，主要爲過去對於稻熱病菌之變異性未盡瞭解，而所採用之抗病親本實未具有高度的抗病性之故[8]。近年來經許多學者專家之研究，吾人對於稻熱病菌的變異知識漸增[4,19,30,31,32,34]，惟國內以往抗病育種之選拔僅限於一地或一時利用自然發病環境篩選方式，而對於選出之抗病品種（系）其抗病性並未充分瞭解，尤其是品種與小種間之關係不明，雖然有關品種與小種之關係最近已受到國內之重視，但一般仍侷限於新育成品種（系）及秧苗期之檢定[3,20,40]，而對於採用之抗病親本其抗病性背景仍未有詳盡之探討，特別是有關穗稻熱病之資料更付闕如。雖有報告指出秧苗期之抗病性與本田葉稻熱病間有密切關係，但有例外[2,11,12,13,17]，而抗葉稻熱病之品種雖大多對穗稻熱病亦具抵抗性，但亦有對兩者反應不一之品種[10,12,13,17,36]，此係致病性小種之不同抑或其他如氣象環境因素等之差異所致，

1.臺灣省農業試驗所 研究報告第1076號。本研究承中央研究院吳信淦博士及農藝系主任張萬來博士指導與斧正，謹此致謝。

2.本所嘉義農業試驗分所助理研究員。臺灣省 嘉義市。

實有待進一步之探討。

本試驗目的即欲測定國內外採用之抗病親本及育成之抗病品種（系）對本省主要稻熱病菌生理小種之反應，期能選得抗病性穩定之種源做爲今後抗病育種之材料，並探討水稻品種（系）對葉及穗稻熱病反應之相關及期作、接種源等與抗病性之關係，以爲抗稻熱病育種之參考，並供抗病遺傳分析之基礎。

材料與方法

一、水稻品種（系）對本省主要稻熱病菌生理小種之反應：

參試品種（系）爲從國際稻米研究所（IRRI）引進之抗病親本 Tetep 等和日本育成之抗病品種 Fukunishiki 以及本省近年來育成之抗病品種臺農 62 號等計 18 個品種（系），另加臺農 67 號及 Lomello 爲對照。接種源爲近年來本省主要流行之 IF2, IF4, IG1, IG2, IH1 及 II-1 等六個小種 [3]。試驗方法詳述如下：

1.葉稻熱病檢定：

(1)秧苗期檢定：

參試品種（系）種子經消毒催芽後，播種於直徑 8cm 之塑膠缽中，每缽種一品種（系）4 株，每品種（系）重復 3 次即種 3 缽12株，播種後 3 週，待秧苗長至 4 — 5 葉時，每株選取剛長出不久的新葉三片，採用多菌系接種法（multiple inoculation method）[42]，以原子筆蕊尖在每片葉上挫傷 6 點，每點距離 1～2cm，隨後將分別培養於糙米培養基上之各小種胞子以0.02%之 Tween 洗下，經過濾後調配成濃度約1.5～3.0×10^6 個/ml 之胞子懸浮液，每ml懸浮液並加入 10mg 之 Sodium carboxylmethyl cellulose（CMC）使成粘稠狀，然後以吸管將各小種之胞子懸浮液分別點接在不同之挫傷點上，如此同一葉片上可同時接種六個小種，接種後將植株移置濕度保持在90%以上之塑膠罩中，爲首18個小時保持 26°C，以後維持23°C，接種後 7 天，判讀各品種（系）與小種間之反應，調查方法依其病斑反應分爲 A、B、C、D及 E 等五種病斑型，A 及 B 型病斑視爲抗病（R），C、D 及 E 型病斑視爲感病（S），其調查標準如下：

病斑型	標準
A	病斑呈方圓形，約與傷口同大，約 1.5～2.0mm，病斑中心及邊緣呈褐色或淡褐色。
B	病斑呈方圓形或略不規則形，具細褐條，病斑大小與 A 斑相似或稍大，中心呈褐色或淡褐色。
C	病斑呈橢圓形或微不規則，大小約 2～3mm 或略大，病斑中心淡褐色，周緣及外圍呈褐色。
D	病斑呈紡錘形，大小約 3～4mm，中心呈灰白色或淡褐色，周緣褐色，外圍微黃，偶具縱走褐條。
E	病斑呈紡錘形或橢圓形，大小約 4mm～1.2cm，病斑中心除挫傷處微褐外餘呈綠灰白色，周緣淡褐色，外圍呈黃色。

(2)分蘖盛期（本田期）檢定：

供試品種（系）育苗後栽植於水泥槽中，每品種（系）種一行 5 株，單本植，行株距25×20cm，生育期間之施肥管理等按照稻熱病統一病圃檢定標準法 [12,13] 實施，於分蘖盛期（插秧後約40～50天），每株選取適當葉片三張，採用與秧苗期檢定相同之多菌系接種法在同一葉片上點接六個小種，每品種（系）接種15個葉片，接種工作在傍晚時分進行，接種後隨即套以塑

膠袋，接種後7天調查各品種（系）對小種之反應，調查方法與標準同前所述。

2.穗稻熱病（抽穗期）檢定：

將曾經分蘖盛期葉稻熱病檢定之稻株，於抽穗前挖起置陶盆中並移置溫室內，當稻穗抽出劍葉時，於傍晚時分，以注射器從穗頂注射胞子懸浮液，每穗接種一小種之胞子懸浮液 1ml，胞子濃度為 1.0×10^6 個／ml，每品種（系）每小種接種5～6穗，接種後溫度保持 28°C，並隨時以細霧加濕器（Humidifier）維持濕度在 90%以上，接種後7天調查各穗之發病情形，如接種穗其穗柄，穗頸，主枝梗，小枝梗及谷粒上有明顯之稻熱病斑（暗褐色病斑，中央部份灰白色）或整穗枯死者視為感病穗。

二、水稻品種（系）在稻熱病統一病圃之反應：

參試品種（系）同試驗一，試驗方法及調查標準等與本省現行稻熱病統一病圃檢定方法相同[13]。

三、水稻品種在不同期作對不同接種源之反應：

供試品種包括臺南5號及臺農67號兩個稉稻品種和嘉農秈8號、11號兩個秈稻品種，另以崑山五香稉為對照。參試品種分別在第一、二期作插植於 24×18cm 之陶盆中，每盆種1株，每品種種12盆計12株，生育期間之施肥量及管理等按照稻熱病統一病圃方法實施。插秧後約40～50天即分蘖盛期，分別以本省分佈頻度最高之三個稻熱病菌生理小種 IF4, IG2, II1 之個別胞子懸浮液及三個小種之等量混合胞子懸浮液暨採自統一病圃罹病品種葉片上洗出之自然胞子等以前述多菌系接種法點接於各品種之新葉片上，胞子懸浮液濃度約為$1.5 \sim 3.0 \times 10^6$個/ml，每株接種三張葉片，每品種接種10株計30個葉片，即每接種源在每品種上接種30點，接種後7天，調查各品種對不同接種源之反應。抽穗期，於傍晚時分以前述注射法行人工穗接種，接種後隨即套袋，接種後7天行穗稻熱病調查，調查方法同試驗一。

四、水稻品種在不同期作於稻熱病統一病圃之反應：

參試品種同試驗三，供試品種在一、二期作種植於稻熱病統一病圃水田及旱田式病圃，生育期間之肥培管理及發病調查等均依照現行統一病圃檢定方法實施。

試驗結果與討論

一、水稻品種（系）對本省主要稻熱病菌生理小種之反應：

參試二十個品種（系）對本省主要流行之 IF2 等六個稻熱病菌生理小種之抵抗性反應詳如表1，由此表可以看出秧苗期對六個小種均表現抗病的有臺東29號等15個品種（系），分蘖盛期抗六個小種的亦為臺東29號等15個品種（系），而抽穗期抗六個小種的有臺東29號等12個品種（系）。在秧苗期、分蘖盛期（即葉稻熱病）及抽穗期（即穗稻熱病）對六個小種均表現抗病反應的有臺東29號等12個品種（系）。

就不同稻型而言，稉稻品種抗六個小種的只有臺東29號和臺南6號，從日本引進之 Fukunishiki 只抗 IF2 及 IG2 兩個小種，而對 IF4 等四個小種感病，另高雄141號及臺農62號對 IG1 及 IH1感病，對照品種臺農67號則對 IF2, IG1 及 IG2 等三個小種感病。秈稻品種（系）則除對照品種Lomello 外，其他13個品種（系）在秧苗期及分蘖盛期對六個小種均表現抗病，惟抽穗期有IR1544-238-2-3 對 IG1 及 IH1 兩個小種感病，Carreon 對 IF2 感病，另 Tadukan 對 IH1 感病。由上觀之，秈稻對本省六個主要生理小種之抵抗性較稉稻為强，此或係本省稻作栽培面積中稉稻佔90%以上[14]，因此能攻擊稉稻之小種普遍廣泛分佈且頻度甚高，而為害秈稻之小種數可能較少且頻度較低使然，亦即水稻品種栽培面積之多寡影響小種的分佈[3,21]。

依水稻品種（系）在秧苗期及分蘖盛期對葉稻熱病之反應觀之，參試品種（系）在秧苗期及分蘖盛期對各小種之反應均極一致，顯示秧苗期對某小種表現抗病者，其在分蘖盛期對該小種亦表現抗病

表 1. 水稻品種（系）對本省主要稻熱病菌生理小種之反應

Table 1. Reaction of rice varieties and selections to local major blast races

品種（系） Variety or selection	稻型 Type	IF 2	IF 4	IG 1	IG 2	IH 1	II 1
生理小種 Race / 接種期 Inoculated stage / 反應 Reaction		秧苗期 分蘗盛期 抽穗期 (Seedling stage, Active tillering stage, Heading stage)	秧苗期 分蘗盛期 抽穗期 (Seedling stage, Active tillering stage, Heading stage)	秧苗期 分蘗盛期 抽穗期 (Seedling stage, Active tillering stage, Heading stage)	秧苗期 分蘗盛期 抽穗期 (Seedling stage, Active tillering stage, Heading stage)	秧苗期 分蘗盛期 抽穗期 (Seedling stage, Active tillering stage, Heading stage)	秧苗期 分蘗盛期 抽穗期 (Seedling stage, Active tillering stage, Heading stage)
Fukunishiki	Japonica	R R R*	S S S	S S S	R R R	S S S	S S S
Kaohsiung 141	Japonica	R R R	R R R	S S S	R R R	S S S	R R R
Taitung 29	Japonica	R R R	R R R	R R R	R R R	R R R	R R R
Tainan 6	Japonica	R R R	R R R	R R R	R R R	R R R	R R R
Tainung 62	Japonica	R R R	R R R	S S S	R R R	S S S	R R R
Tainung 67	Japonica	S S S	R R R	S S S	S S S	R R R	R R R
CIAT-ICA 5	Indica	R R R	R R R	R R R	R R R	R R R	R R R
IR1416-128-5-8	Indica	R R R	R R R	R R R	R R R	R R R	R R R
IR1544-238-2-3	Indica	R R R	R R R	R R S	R R R	R R S	R R R
IR1905-pp11-29-4-61	Indica	R R R	R R R	R R R	R R R	R R R	R R R
IR3259-5-160-3	Indica	R R R	R R R	R R R	R R R	R R R	R R R
IR4547-2-1-2	Indica	R R R	R R R	R R R	R R R	R R R	R R R
IR5533-pp854-1	Indica	R R R	R R R	R R R	R R R	R R R	R R R
IR9660-00948-1	Indica	R R R	R R R	R R R	R R R	R R R	R R R
Ta-poo-cho-z	Indica	R R R	R R R	R R R	R R R	R R R	R R R
C46-15	Indica	R R R	R R R	R R R	R R R	R R R	R R R
Carreon	Indica	R R S	R R R	R R R	R R R	R R R	R R R
Tetep	Indica	R R R	R R R	R R R	R R R	R R R	R R R
Tadukan	Indica	R R R	R R R	R R R	R R R	R R S	R R R
Lomello	Indica	S S S	S S S	S S S	S S S	S S S	S S S

*R＝抗病 Resistant；S＝感病 Susceptible

反應。反之，秧苗期對某小種感病者，其在分蘗盛期對該小種亦呈感病反應。另就水稻品種（系）對葉及穗稻熱病之抵抗性關係而言，雖然大多數品種（系）對各小種之葉及穗稻熱病之抵抗性反應大體一致，但仍有少數品種（系）如 IR1544-238-2-3, Carreon 及 Tadukan 等對某些小種其葉雖表現抗病，但穗却呈感病反應，以往亦有類似之報告 [30]。

二、水稻品種（系）在統一病圃對稻熱病之反應：

參試品種（系）在嘉義農業試驗分所水田式及旱田式病圃對稻熱病之反應詳如表2，在旱田式病圃（即秧苗期）對葉稻熱病呈感病反應的只有臺農67號及 Lomello 兩個感病對照品種，其餘 Fukunishiki 等18個品種（系）均表現抗病，惟其中臺南6號及 IR1544-238-2-3 爲中抗反應。水田式病圃（即分蘖盛期）葉稻熱病檢定結果與旱田式病圃檢定結果頗相符合，兩者間之相關係數達極顯著水準（r=0.9859**），惟水田式病圃之發病程度略較旱田式病圃輕微，可見旱田式病圃之檢定結果足可代表供試品種（系）在水田式病圃之反應，由於設置旱田式病圃不但較水田式病圃節省人力、物力且有管理方便，發病均一等優點，故爾後抗葉稻熱病檢定似可在旱田式病圃實施即可。

就水稻品種（系）對穗稻熱病之抵抗性而言，參試20個品種（系）中，抗穗稻熱病者有 CIAT-ICA5 等12個品種（系），惟該等品種（系）均爲秈稻，稉稻品種則均呈感病反應（中感至感），其中以臺南6號及臺農67號較嚴重。秈稻品種（系）中只有 IR1544-238-2-3 表現感病，其他均爲抗病反應，此亦顯示秈稻對穗稻熱病之抵抗性亦較稉稻爲强。

再依水稻品種（系）對葉及穗稻熱病之抵抗性關係觀之，參試品種（系）對葉稻熱病之抵抗性似較穗稻熱病爲强，一般抗葉稻熱病之品種（系）在後期對穗稻熱病之抵抗性亦較强，而感染葉稻熱病之品種（系）對穗稻熱病亦多呈感病反應，兩者間有極顯著之相關關係（r=0.639**），此顯示抗葉

表 2. 水稻品種（系）在統一病圃對稻熱病之反應

Table 2. Reaction of rice vacieties and selections to blast in the uniform blast nursery

級數及反應 Score and reaction ／ 稻熱病 Blast ／ 病圃 Nursery ／ 品種（系） Variety or selection	葉稻熱病 Leaf blast		穗稻熱病 Panicle blast
	旱田式病圃 Upland nursery	水田式病圃 Paddy nursery	水田式病圃 Paddy nursery
Fukunishiki	2(R)*	2(R)*	5(MS)**
Kaohsiung 141	2(R)	2(R)	5(MS)
Taitung 29	2(R)	2(R)	5(MS)
Tainan 6	4(MR)	4(MR)	7(S)
Tainung 62	2(R)	2(R)	5(MS)
Taitung 67	9(HS)	8(S)	7(S)
CIAT-ICA 5	2(R)	2(R)	0(HR)
IR1416-128-5-8	2(R)	2(R)	0(HR)
IR1544-238-2-3	4(MR)	4(MR)	5(MS)
IR1905-pp11-29-4-61	2(R)	2(R)	0(HR)
IR3259-5-160-3	2(R)	2(R)	0(HR)
IR4547-2-1-2	2(R)	2(R)	0(HR)
IR5533-pp854-1	2(R)	2(R)	1(R)
IR9660-00948-1	2(R)	2(R)	1(R)
Ta-poo-cho-z	2(R)	2(R)	0(HR)
C46-15	2(R)	2(R)	0(HR)
Carreon	2(R)	2(R)	0(HR)
Tetep	2(R)	1(R)	0(HR)

Tadukan	2(R)	1(R)	0(HR)
Lomello	9(HS)	9(HS)	—

* Leaf blast scores and reactions：
0=HR (Highly resistant)； 1～3=R (Resistant)； 4～5=MR (Moderately resistant)；
6=MS (Moderately susceptible)； 7～8=S (Susceptible)； 9=HS (Highly susceptible)

**Panicle blast scores and reactions：
O=HR (Highly resistant)； 1=R (Resistant)； 3=MR (Moderateley resistant)；
5=MS (Moderately susceptible)； 7=S (Susceptible)； 9=HS (Highly susceptible)

稻熱病之品種（系）可能秉具抗葉及穗稻熱病之遺傳基因，或抗葉稻熱病之基因對於穗稻熱病亦具有效應[18]。惟有些品種（系）在生育前期雖然抗葉稻熱病，但後期却感染穗稻熱病，這或係此等品種（系）僅具抗葉稻熱病之基因[18]，也可能係後期病圃中有不同致病性之小種存在[8,36]，且穗稻熱病之發生易受抽穗期氣象因素所影響[36]。因此現行統一病圃穗稻熱病檢定方法實有待進一步之檢討。

根據人工接種及統一病圃檢定結果比較，兩種方式檢定結果大致相符，人工接種結果顯示能抵抗多數小種之品種（系）在統一病圃亦多表現抗病，即水稻品種（系）之罹病程度視能侵害它的小種數而定，在病圃高度感病品種（系）可能係由於既存多數小種或高頻度單一小種能攻擊它之故，相反的，具有高度抵抗性的品種（系）可能只受到少數低頻度小種或根本沒有小種能侵襲它[40]。Ou 等[37]亦報告能抵抗多數小種或菌株的品種只有少數病斑，在田間所見病斑數（量的表現）之差異即爲品種對小種（質的表現）反應的指標，而量的抵抗性 (quantitative resistance) 係質的抵抗性 (qualitative resistance) 的綜合表現，具有廣幅抵抗性 (broad spectrum of resistance) 的品種通常僅有少數病斑，抗幅愈廣，病斑數愈少[33]。

若就參試品種（系）之抗病來源及近五年來在本省檢定結果（表 3）觀之，原產日本之 Fukunishiki 其抗病源係來自美國稻 Zenith，據日人報告指稱其具有 Pi-z 之抗病基因，它在日本之抗病年限有 5 年[41]。推究原因可能係其抗病親本 Zenith 具有較廣域之抗病性，因此 Zenith 不但能抵抗多數美國小種[15]，且對90%以上之菲律賓小種表現抗病[9]，而在本省歷年來之檢定結果亦均表現抗病[13]。雖然 Fukunishiki 在本省病圃近年來均表現抗病，但經人工接種發現其對 IF4, IG1 及 IH1, II1 等四個小種感病，此係發病環境之不同，抑或病圃中自然界小種間擷抗作用 (antagonism) 之結果，有待進一步之探討。本省育成之四個稉稻品種，除臺農62號之抗病源係來自 CI5309 外，其他高雄 141號、臺東29號及臺南 6 號等均來自中國大陸品種荔枝紅，由於抗病性之遺傳背景相同，

表 3. 水稻品種（系）之抗病來源及其近五年來在本省之抵抗性反應

Table 3. The resistant sources of rice varieties and selections to blast and the reaction to blast during the last five years in Taiwan

品種（系） Variety or selection	原產地 Origin	組合 Cross	抗病源 Resistant sources	抗病級數 Leaf blast score 六六年（一九七七）	六七年（一九七八）	六八年（一九七九）	六九年（一九八〇）	七〇年（一九八一）
Fukunishiki	Japan	Hatsunishiki/BC-68	Zenith	—	—	1*	2	2
Kaohsiung 141	Taiwan	Kaohsiung 139//Kaohsiung yu 973/Kaohsiung tsao-yu 21	Lit-chi-hung	—	—	3	2	2
Taitung 29	Taiwan	Hounenwase/Taitung yu 265²	Lit-chi-hung	2	2	2	3	2

Tainan 6	Taiwan	Tainan 5/Kaohsiung 135	Lit-chi-hung	4	5	7	7	4
Tainung 62	Taiwan	Hsinchu 56//CI5309/Hsinchu 56	CI5309	6	4	3	2	2
Tainung 67	Taiwan	Taichung shih 138/Tainung 61^2	—	9	9	9	9	9
CIAT-ICA 5	Colombia	CICA4//IR665-23-1-1/Tetep	Tetep	1	1	1	1	2
IR1416-128-5-8	IRRI	IR400-28-4-5/Tetep	Tetep	1	1	1	1	2
IR1544-238-2-3	IRRI	IR24/Tetep	Tetep	2	1	3	3	4
IR1905-pp11-29-4-61	IRRI	IR8/Tetep	Tetep	1	1	1	1	2
IR3259-5-160-3	IRRI	$IR8^3$/Tetep	Tetep	1	1	2	1	2
IR4547-2-1-2	IRRI	IR3273//IR4477B/IR3265	Tetep, PK 203	1	1	1	1	2
IR5533-pp854-1	IRRI	$IR8^2$/Carreon//IR8/Tetep	Carreon, Tetep	1	1	1	1	2
IR9660-00948-1	IRRI	$IR8^6$/IR3260	Dawn, KAK	2	1	2	1	2
Ta-poo-cho-z	China mainland			2	1	1	1	2
C46-15	Burma			1	1	1	1	2
Carreon	Philippine			2	1	1	1	2
Tetep	Vietnam			1	1	1	1	2
Tadukan	Philippine			1	1	1	2	2
Lomello	Italy			9	9	9	9	9

*See footnote on Table 2.

若此遺傳基因失去抗性時，來源相同之抗病品種均有先後失去其抗病性之可能，事實顯示臺南 6 號及臺東29號在命名推廣之同一年度在某些地區即發生感病現象，而高雄 141號亦只有一年之抗病壽命，臺農62號較長亦僅有二年（表 4），國外亦有相似之情形 [26,31,32,41]。另哥倫比亞（Colombia）育成之 CIAT-ICA5 及國際稻米研究所(IRRI)育成之 IR1416-128-5-8, IR1905-pp11-29-4-61, IR1544-238-2-3 及 IR3259-5-160-3 等品系之抗病源均來自原產越南（Vietnam）之 Tetep ，而 IR5533 除含有 Tetep 之基因外尚含有 Carreon 之抗病性 ，IR4547-2-1-2 則有 Tetep 及 Pankhari203 之抗病基因，另 IR9660-00948-1 之抗病源來自 Dawn 及 Kataktara。上述 Tetep 等抗病源經國際稻熱病圃（IRBN）十數年來在全世界主要產米地區參加數百次之檢定結果，顯示均具有高水準之抗病性，其抗病率均達95%以上，可謂之具有廣幅抗病性 [9]。而各品系中除 IR1544-238-2-3 在穗接種時對 IG1 及 IH1 兩小種感病外 ，其他品系不論在人工接種區或自然病圃均表現高度之抗病性，且近五年來在國際稻熱病檢定圃亦均表現具有如其抗源 Tetep 等之高度穩定抗病性 [25] ，是爲目前抗稻熱病育種最好之親本材料，尤其是 IR4547-2-1-2 尙具有 Mudgo 抗褐飛蝨之特性，更是抗病抗蟲育種之理想親本，惟此等品系其農藝性狀如株型、產量及品質等均不如理想，且多晚熟並均屬秈稻，欲將其抗病性轉移至優良稉稻上，可能需要花費相當之時間及人力，因此似可利用此等材料先與優良稉稻品種雜交，先育成具有不同抗病基因之中間品種或橋樑品種，再將此等中間品種互交或多次雜交以累積不同抗源基因育成具有高度持久抗病性之稉稻品種或育成具不同抗源之多品系品種，目前臺灣省農業試驗所及嘉義農業試驗分所已朝此目標邁進，並已有初步成果 [1]。

表 4. 本省水稻抗病品種之罹病化情形

Table 4. The loss of resistance in some resistant rice varieties in Taiwan

品種 Variety	推廣年度 Year released	罹病年度 Year became suscep.	罹病地區 Areas found suscep.	抗病年限 Resistant period
Tainan 6	1975	1975	Taitung	0
Tainung 62	1975	1977	Taichung, Chiayi	2
Taitung 29	1979	1979	Taitung	0
Kaohsiung 141	1980	1981	Taichung, Taitung	1
Average				0.75

三、水稻品種在不同期作對不同接種源之反應：

參試品種在七十年第一、二期作以不同來源稻熱病菌胞子接種結果（表 5），顯示臺南 5 號不論葉或穗在一、二期作對各接種源均表現感病，可見臺南 5 號爲一極感病品種。臺農 67 號不論期作對 IG2 及一、二期作統一病圃感病品種上洗出之自然胞子感病，此顯示臺農67號亦爲一頗感病品種，惟其葉對 IF4, IG2 及 II1 三個小種之混合胞子表現抗病反應，這可能因其對混合胞子中之 IF4 及II1 兩個小種抗病，而僅對 IG2 感病，因此混合懸浮液中對臺農67 號有致病能力之胞子數僅爲全部胞子之三分之一，其致病能力可能受到無致病性小種 IF4 及 II1 所抑制，使其病斑侷限於接種部位不能向外擴展而呈現抗病型病斑。曾有報告指出以致病性小種與無致病性小種混合接種所形成之病斑較以

表 5. 水稻品種在不同期作對不同稻熱病菌接種源之反應

Table 5. Reaction of rice varieties to different blast inocula in different crops

稻型 Type	品種 Variety	期作 Crop	IF 4 葉 Leaf	IF 4 穗 Panicle	IG 2 葉 Leaf	IG 2 穗 Panicle	II 1 葉 Leaf	II 1 穗 Panicle
Japonica	Tainan 5	1st crop	S*	S	S	S	S	S
		2nd crop	S	S	S	S	S	S
Japaonica	Tainung 67	1st crop	R	R	S	S	R	R
		2nd crop	R	R	S	S	R	R
Indica	Chianung sen 8	1st crop	R	S	R	R	R	S
		2nd crop	R	S	R	R	R	S
Indica	Chianung sen 11	1st crop	R	R	R	S	R	S
		2nd crop	R	R	R	S	R	S
Japonica	Kung-shan-wu-shen-ken	1st crop	S	S	S	S	S	S
		2nd crop	S	S	S	S	S	S

(Header diagonal cell: 反應 Reaction; 接種源 Inoculum; 稻熱病 Blast)

稻型 Type	品種 Variety	期作 Crop	三小種混合 Mixture of IF4, IG2 and II1		一期病圃胞子 Inoculum from 1st crop blast nursery		二期病圃胞子 Inoculum from 2nd crop blast hursery	
			葉 Leaf	穗 Panicle	葉 Leaf	穗 Panicle	葉 Leaf	穗 Panicle
Japonica	Tainan 5	1st crop	S	S	S	S		
		2nd crop	S	S	S	S	S	S
Japonica	Tainung 67	1st crop	R	S	S	S		
		2nd crop	R	S	S	S	S	S
Indica	Chianung sen 8	1st crop	R	S	R	S		
		2nd crop	R	S	R	S	R	R
Indica	Chianung sen 11	1st crop	R	S	R	S		
		2nd crop	R	S	R	S	R	S
Japonica	Kung-shan-wu-shen-ken	1st crop	S	S	S	S		
		2nd crop	S	S	S	S	S	S

*See footnote on Table 1.

單一致病性小種接種者爲小，且其病斑面積受抑制之程度隨混合液中無致病性小種胞子濃度之增加而加鉅，據推測可能有抗生素物質（antibiotic substance）在緊接著接種部份產生之故，而兩個不同致病性小種間之相互作用（interaction），似與侵入之無致病性小種導致植株產生過敏性反應（hypersensitive reaction）有關[29]。Kiyosawa 和 Fujimaki[27] 以相異致病性小種混合接種結果亦發現有抑制效應（inhibiting effect）存在。另 Takahashi[38] 亦觀察到致病菌系之發育有受到先行接種之無致病性菌系抑制之現象。雖然臺農67號在生育前期（葉稻熱病）對三個小種之混合胞子抗病，但在後期（穗稻熱病）却呈感病反應，此或因穗接種係將胞子懸浮液注射入剛抽出之稻穗內，斯時稻穗大部份尙包在葉鞘內，其環境較有利於稻熱病菌之侵入爲害，抑或只要少數胞子即可引發穗稻熱病[7]。嘉農秈 8 號其葉在一、二期作對各接種源均呈抗病反應，但穗則對 IF4, II1 及三個小種混合液和一期作自然胞子感病，而僅抗二期病圃自然胞子，這可能係二期作病圃中沒有對嘉農秈 8 號有致病性之小種存在，或雖有致病性小種但其頻度很低不足爲害故也。嘉農秈11號其葉在一、二期作對各接種源亦均呈抗性反應，但穗則除 IF4 外對其他接種源均表現感病，由此可見嘉農秈 8 號及11號兩個秈稻品種其葉及穗對各接種源之反應似並不一致，這可能是此兩品種其穗對各接種源比較敏感，亦或僅具抗葉稻熱病之基因而欠缺抗穗稻熱病基因，以往田間統一病圃檢定結果，秈稻品種（系）之穗稻熱病亦遠較葉稻熱病嚴重[17]。感病對照品種崑山五香稉不論期作及葉、穗對任何接種源均表現感病。

由以上人工接種檢定結果，顯示水稻品種在不同期作對同一接種源之反應均頗一致，並不因期作而有所差異，因此水稻在不同期作下而有不同之反應，主要可能係因不同期作而田間存在之小種族羣不同或小種頻度相異所致，當然氣象因素亦是影響稻熱病發生之一大要因[6,7]。

四、水稻品種在不同期作於統一病圃之反應：

七十年第一、二期作參試品種在稻熱病統一病圃對稻熱病之反應詳如表 6，由表 6 可以看出一期

作臺南 5 號及臺農67號兩個稉稻品種不論在水田或旱田式病圃其罹病程度均較二期作嚴重，尤以穗稻熱病爲甚，而嘉農秈 8 號及11號兩秈稻品種之反應則適與稉稻相反，即秈稻在二期作之罹病率較一期

表 6. 水稻品種在不同期作於稻熱病統一病圃之反應

Table 6. Reaction of rice varieties to blast at uniform blast nursery in different crops

稻 型 Type	品 種 Variety	葉稻熱病 Leaf blast				穗稻熱病 Panicle blast	
		一期作 1st crop		二期作 2nd crop		一期作 1st crop	二期作 2nd crop
		旱田式病圃 Upland nursery	水田式病圃 Paddy nursery	旱田式病圃 Upland nursery	水田式病圃 Paddy nursery		
Japonica	Tainan 5	9(HS)*	6(MS)	7(S)	4(MR)	9(HS)**	1(R)
Japonica	Tainung 67	9(HS)	8(S)	8(S)	5(MR)	7(S)	3(MR)
Indica	Chianung sen 8	2(R)	2(R)	5(MR)	4(MR)	3(MR)	5(MS)
Indica	Chianung sen 11	4(MR)	4(MR)	6(MS)	4(MR)	3(MR)	7(S)
Japanica	Kung-shan-wu-shen-ken	9(HS)	9(HS)	9(HS)	6(MS)	—	9(HS)

*and **see foothnote on Table 2.

作爲高，且亦以穗稻熱病在期作間差異較顯著。蔡[5]亦曾報告類似之現象。簡氏[10]亦指出嘉農秈 8 號及11號在二期作甚易感染穗稻熱病。Chang 等[16]亦曾報告秈稻品種（系）在民國65年二期作其感病品種（系）數約爲一期作之3.5～4.5倍（葉及穗稻熱病）。在韓國，Chung[22]亦報告經接種後之秈稻品種在高溫時較在低溫時產生較多感病型病斑，而稉稻則呈相反之反應。Hashioka[23]亦曾報告一般產自溫帶地區之品種在低溫下較熱帶品種易感病。稉稻品種在低溫時較易感病，而秈稻則反在高溫時較易罹病，這可能因爲害稉稻之生理小種在較低溫時發生頻度較高，且其致病性亦較强，而在高溫時則爲害秈稻之生理小種較多且較具致病性使然[17]。Tseng 等[39]曾報導從二期作分離出之稻熱病菌株在高溫下培養時其生長率顯較第一期作菌株爲高。又在高溫下稻株形態及營養狀況亦可能使秈稻品種更易受稻熱病之侵襲[24]。

目前本省稻熱病統一病圃均在第一期作設置，且各場所對抗病性之篩選亦多在一期作進行，惟由於稉稻品種在一期作較易感病，而秈稻在二期作感病的品種（系）往往在第一期作檢定時並不發病，故若僅在一期作檢定或篩選則常有逃避現象，而獲得不正確之結果或選取感病之個體或系統，因此今後抗病育種之選拔與檢定，稉稻似可在一期作進行，而秈稻則應在二期作實施爲宜。

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Studies on the Reaction of Rice Varieties and Selections to Blast Disease[1]

Lung-Che Chen[2]

Summary

The purposes of this experiment were to test the domestic and introduced resistant varieties and selections to local major physiological races of blast and to investigate the relationship between leaf blast and panicle blast in rice. In addition, the association between season, inoculum and varietal resistance were also evaluated. The results are briefly summarized as followed:

1. A total of 20 varieties and selections were inoculated with six local main physiological races, and the results indicated that 12 (60%) were resistant to all races inoculated, all being Indicas except Tainan 6 and Taitung 29 which are Japonicas. In general, entries resistant to leaf blast were mostly resistant to panicle blast with some exceptions.
2. There was a close correlation between the results of uniform nursery and artifical inoculation test. Varieties and selections with higher resistance to blast in the nursery were resistant to more races and vice versa. Based on the results of this study, entries such as CIAT-ICA5, IR1416-128-5-8, IR1905-pp11-29-4-61, IR3259-5-160-3, IR4547-2-1-2, IR5533-pp854-1 and IR9660-00948-1 appeared to have higher level of resistance to blast and therefore can be used as sources of resistance in a future breeding program.
3. The same reaction of entry to inoculum was found in the first and second crops of 1981, and in both Indica and Japonica rices.
4. The disease incidence of Tainan 5 and Tainung 67 were more severe in the first crop while those of Chianung sen 8 and Chianung sen 11 were more sensitive in the second crop, particularly to panicle blast.

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1. Contribution No. 1076 from Chiayi Agricultural Experiment Station. TARI.

2. Assistant Agronomist, Chiayi Agricultural Experiment Station, TARI. Chiayi, Taiwan 600, ROC.

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稻米粒品質之改良

Ⅱ 米粒膠體硬度及顆粒澱粉含量之遺傳[1]

郭 益 全　　謝 順 景[2]

摘要：本研究使用嘉農秈11號×臺農67號及臺南5號×臺中在來1號等兩個秈稉異型稻間之雜交 F_2 集團爲材料，測定各單株米粒之顆粒澱粉含量及膠體硬度等兩個主要食用品質性狀，以闡述秈稉雜交後代米粒食用品質之遺傳行爲，結果獲知：

1.兩雜交組合 F_2 集團膠體硬度之頻度分布爲具尖峰之偏歪分布，且均可分成3高硬度：1低硬度之比例，符合孟德爾氏單性雜種分離之遺傳理論。

2.兩雜交組合 F_2 集團顆粒澱粉含量的頻度呈常態分布，唯分布之平均恰落在低含量親本均值附近，且有相當多數之個體向左超越低含量之親本，顯示顆粒澱粉含量雖屬量的性狀，但仍極易選獲具有理想顆粒澱粉含量之單株。

3.在嘉農秈11號×臺農67號組合，穀殼苯酚反應陰性者之膠體硬度之平均值(41.7mm)顯著地高於陽性反應者(36.6mm)。表示陽性反應者(一般爲秈稻)之米粉膠體較硬；陰性反應者(一般爲稉稻)較輭。但陽性與陰性反應二羣之顆粒澱粉含量平均依次爲19%與18.6%，並無差異存在。

4.膠體硬度與顆粒澱粉含量成極顯著之負相關；而兩者與其他產量構成性狀則無相關關係。

5.膠體硬度及顆粒澱粉含量之廣義遺傳率值均很高，膠體硬度約90%左右，顆粒澱粉含量則在77%之譜。

一般，米飯之風味品評(taste panel scores)主要由飯粒之黏著度(cohesiveness)、柔軟性(tenderness)及光澤度(gloss)來決定[12,17,19]。而米粒之顆粒澱粉含量(amylose content)長久以來向被認爲是影響此等風味品評等第之最主要因素[10,11,12,15,16,18,20]。一般，顆粒澱粉含量低之米飯濕粘而具光澤，絕大多數之稉稻屬之；顆粒澱粉含量高之米飯則乾鬆而質地粗硬，大部分之秈稻屬之。故隨消費者嗜性之互異，各不同顆粒澱粉含量基準之稻米其受歡迎之情況不僅因人而異，且視區域之不同而異。若本省、日本及韓國則低顆粒澱粉含量之米飯受歡迎，而印度及菲律賓地區之消費者則偏愛顆粒澱粉含量中等之稻米[15]。

Cagampang *et al*[6] 首先證實同顆粒澱粉含量等級之不同稻品種中，其食用品質(eating quality)仍有差異存在[21,22]，接著許多報告陸續指出米粒之膠體硬度(gel consistency)得爲同顆粒澱粉含量稻米食用品質之指標[21,22]。而由於膠體硬度之測定簡便快捷，故若干學者[1,22]認爲在育種過程中，膠體硬度之測定可補救顆粒澱粉含量定量費時之短，而同爲篩選特定食用品質之指標。

目前，有關米粒顆粒澱粉含量之遺傳研究尚陸續見有報告[5,8,23]，而有關米粒膠體硬度之報告則甚少[8]。故 Chang and Somrith[7] 建議究明膠體硬度之遺傳行爲。然而，此等已發表之研究概爲同型間雜交遺傳行爲之闡明[5,8,23]，至於食用品質互異之秈稉稻雜交後代食用品質之遺傳則闕如，前報[3,4]陸續報告秈稉稻雜交後代各產量構成性狀之遺傳與變異；並探討 F_2 世代單株產量構成性狀對

1.臺灣省農業試驗所　研究報告第1077號。

2.本所農藝系助理研究員、前研究員兼主任。臺灣省　臺中縣　霧峰鄉。

單株穀產量變異性之影響，本文則報告秈稉稻雜交 F_2 集團有關食用品質之種種遺傳訊息。俾更充實秈稉稻雜交之遺傳育種知識。

材料與方法

供試水稻材料計有嘉農秈11號×臺農67號及臺南 5 號×臺中在來 1 號等兩個雜交組合。1979年二期作，每親本各插植 5 行；每組合32行；每行12株；單本植。行株距 25×25cm，肥料用量 N：P：K＝90：40：60（kg/ha）。收穫時每組合及各該親本均去邊行；每行去首尾株。調查與分析項目計有穗數、平均一穗粒數、結實率、千粒重及米粒之膠體硬度及顆粒澱粉含量。其中，米粒之膠體硬度的測定係採 Cagampang *et al* (6) 之方法；米粒之顆粒澱粉含量的定量則按 Juliano (13) 之方法進行。

結　果

一、秈稉雜交 F_2 集團米粒膠體硬度之分離

茲將兩秈稉雜交組合 F_2 集團膠體硬度之測定值按組合別暨適當之組距 (2) 編列成頻度分布表（表 1），並根據費氏（R. A. Fisher）之理論估算該頻度分布之歪度（skewness）與峰度（kurtosis）估值，同時給予適當之顯著性測定（表 2），以初步描述秈稉雜交組合米粒膠體硬度之分離情形。

表 1 平均值顯示，兩雜交組合之秈稻親本的米粉膠體之展流長度較短，均約 24mm 左右；而稉稻親本米粉膠體之展流長度則較長，概在 50mm 上下。按 IRRI 之 35mm 以下屬高硬度；35mm 至 50mm 爲中硬度；50mm 以上屬低硬度之膠體軟硬度分類標準 (9) 知，此兩雜交組合之秈稻親本屬高膠體硬度；而稉稻親本則屬低膠體硬度。同表並知兩雜交組合 F_2 分離集團膠體硬度之平均值均恰與兩親之中間值相近。即嘉農秈11號×臺農67號爲 37.7mm；而臺南 5 號×臺中在來 1 號爲 35.7 mm。

表1. 水稻雜交 F_2 集團膠體硬度之變異

Table 1. Variation of gel consistency in the F_2 populations of rice crosses.

Parents and corosses	Gel consistency (mm)													Total	Mean	CV.	Segr. rate	X^2
	20	25	30	35	40	45	50	55	60	65	70	75	80					
Chianung-Sen 11 (P_1)	22	8												30	23.4	0.07		
F_2 ($P_1 \times P_2$)	91	29	12	18	25	17	29	16	9	6	11	2		265	37.7	0.42	3 : 1	0.916ns
	192						73											
Tainung 67 (P_2)				1	5	7	7	6	2	1	1			30	50.5	0.14		
Tainan 5 (P_1)					6	7	12	3	2					30	49.4	0.11		
F_2 ($P_1 \times P_2$)	111	32	12	17	17	13	21	13	11	7	7	2		263	35.7	0.44	3 : 1	0.475ns
	202						61											
Taichung (N) 1 (P_2)	20	10												30	23.9	0.09		

Note : *indica* type : Chianung-Sen 11, Taichung (N) 1
japonica type : Tainan 5, Tainung 67.

表2. 秈稉稻雜交 F_2 集團膠體硬度及顆粒澱粉含量之峰度與歪度

Table 2. Skewness (g_1) and kurtosis (g_2) of gel consistency and amylose content estimated from F_2 populations of the crosses between *indica* and *japonica* rices.

Characters	Chianung-Sen 11×Tainung 67				Tainan 5×Taichung (N) 1			
	g_1	g_2	g_1/SEg_1	g_2/SEg_2	g_1	g_2	g_1/SEg_1	g_2/SEg_2
Gel consistency	1.16	− 0.91	7.74**	− 3.03**	0.82	− 0.65	5.45**	− 2.16*
Amylose content	− 0.18	− 0.38	− 1.20	− 1.21	− 0.16	− 0.36	− 1.06	− 1.20

**Significant at 1% level.

*Significant at 5% level.

兩組合 F_2 集團膠體硬度之頻度分布相當近似，且均為極端偏斜之偏歪分布（表1），由表1再配合表2分布的峰度及歪度估值之顯著性測定知，兩組合 F_2 集團膠體硬度之頻度分布為具尖峰且分布圖形之高峰在左，分布之偏斜在右之非常態分布。此即表示供試兩組合 F_2 集團膠體硬度之平均雖概與兩親之中間值相近，但此兩組合顯然不僅均有相當多數之個體集中在高膠體硬度（即低米粉膠體展流長度）親本附近，且有部分之個體向右超越低膠體硬度（即高米粉膠體展流長度）之親本。此亦即表示在此兩雜交組合中， F_2 分離集團內雖極多數個體之米粒膠體硬度係屬低展流之高硬度，但仍有多數個體之米粒膠體硬度為高展流度之低硬度者，甚或有若干較低硬度親本之膠體更軟之個體出現。

另，由於兩秈稉雜交組合 F_2 集團米粒膠體硬度之頻度分布為具尖峰且偏斜之分布，並未符合典型數量性狀為常態分布之前題，故暫以質的性狀（qualitative character）處理之。將兩雜交組合 F_2 集團諸個體之米粒膠體硬度以米粉膠體展流度為 50mm 者為基點而分成高及低兩羣（表1）。再依兩羣之實際分離情況，設定兩 F_2 集團膠體硬度係3高膠體硬度：1低膠體硬度之單性雜種（

表3. 水稻雜交 F_2 集團顆粒澱粉含量之變異

Table 3. Variation of amylose content in the F_2 populations of rice crosses.

Parents and crosses	Amylose content (%)																							Total	Mean	CV.
	7		9		11		13		15		17		19		21		23		25		27		29			
Chianung-Sen 11 (P_1)														1		2		5		16		5		30	26.5	0.09
F_2 ($P_1 \times P_2$)		2		3		11		31		38		33		63		51		23		10				265	18.9	0.23
Tainung 67 (P_2)										7		15		8										30	19.0	0.06
Tainan 5 (P_1)								1		10		9		8		2								30	18.9	0.13
F_2 ($P_1 \times P_2$)		4		3		41		26		33		70		46		35		5						263	17.1	0.24
Taichung (N) 1 (P_2)																1		11		13		5		30	26.6	0.07

monohybrid）分離之假說，其經卡方適合度測驗結果皆未顯著，顯示，以質的性狀來考慮本研究供試兩雜交組合時，數據肯定膠體硬度高者對低者似為顯性，而由於尚有超越分離現象，故其遺傳機制則除受一對主效因子支配外，可能尚受若干修飾因子（modifiers）所左右。

二、秈稉雜交 F_2 集團米粒顆粒澱粉含量之分離

表 3 為兩秈稉雜交組合 F_2 集團顆粒澱粉含量之頻度分布表，而各該分布之峰度與歪度估值及其顯著性測定則與米粒之膠體硬度頻度分布者同示於表 2 。

由表 3 知，兩雜交組合中秈稻親本的顆粒澱粉含量概在25%以上，即屬於一般所謂高顆粒澱粉含量等級之品種；兩稉稻親本則均在19%左右，屬低顆粒澱粉含量等級之品種。同表並知 F_2 集團顆粒澱粉含量之平均則嘉農秈11號×臺農67號之組合與低含量親本稉稻臺農67號者近似，而臺中在來 1 號×臺南 5 號之組合則尚較低含量親本臺南 5 號為為低。

表 3 亦顯示兩雜交 F_2 集團顆粒澱粉含量之頻度分布亦相當近似，似均為稍帶歪斜之分布，但其經頻度分布峰度與歪度之顯著性測定（表 2 ）知，兩雜交組合 F_2 集團顆粒澱粉含量之頻度分布均屬常態分布。此亦即兩集團中均有相當多之個體集中在集團平均值附近，而因為兩 F_2 集團顆粒澱粉含量之平均概接近低顆粒澱粉含量親本，故此實亦即兩 F_2 集團中有極多數個體之顆粒澱粉含量概變動於低含量親本附近。同時由表 3 並可發現兩集團中皆尚有相當多之個體向左方向超越低顆粒澱粉含量之親本，而超越高含量親本者絕無，此種單方向向左超越低顆粒澱粉含量親本之分離現象，實極有利育種家經由秈稉稻之雜交而達成農藝性狀優良且顆粒澱粉含量低之育種目標。

三、苯酚反應與膠體硬度及顆粒澱粉含量之關係

苯酚反應（phenol reaction）是用以鑑別秈稉型之較常用的方法之一。秈型稻與苯酚反應後穀殼會帶黑褐色，稉型稻則穀殼顏色不變。本研究曾調查嘉農秈11號×臺農67號 F_2 集團中每一單株之苯酚反應。據此將本雜交組合 F_2 集團分成與苯酚有反應（符號為＋，即所謂秈型）與無作用（符號為－，即所謂稉型）等兩羣。並將兩羣之米粒膠體硬度及顆粒澱粉含量之變異列成表 4 及表 5 。由表 4 知，嘉農秈11號×臺農67號之265個 F_2 單株內，屬秈型之個體頗多，計180個；稉型者頗少，有85個。而膠體硬度之平均則秈型為 36.6mm ；稉型較高，達 41.7mm。兩型之差異為 5.1mm，達 5 %之顯著水準（$t=2.32^*$）。然兩型膠體硬度之變異係數則相當近似，指出兩型之膠體硬度之平均雖不等，但兩型膠體硬度分布之變異情形則十分近似。

至於米粒顆粒澱粉含量之型間分布及變異情形一如膠體硬度者。秈型羣之顆粒澱粉含量平均雖略高於稉型羣，但差異不顯著（表 5 ），且兩秈稉羣之變異係數亦十分接近，顯示在嘉農秈11號×臺農67號組合之 F_2 集團中，秈稉兩羣之個體顆粒澱粉含量的變異情形亦十分類似。

表4. 嘉農秈11號×臺農67號組合 F_2 集團中苯酚反應與膠體硬度之關係

Table 4. The relationship between phenol reaction and gel consistency in the F_2 of Chianung-Sen 11 × Tainung 67

Phenol reaction	Gel consitency (mm)													Total	Mean (mm)	CV.	t-value
	20	25	30	35	40	45	50	55	60	65	70	75	80				
Positive reaction	65	19	10	14	21	15	16	7	3	2	6	2		180	36.6	0.40	2.32*
Negative reaction	26	10	2	4	4	2	13	9	6	4	5			85	41.7	0.42	

*Significant at 1% level.

表5. 嘉農秈 11號×臺農67 號組合 F_2 集團中苯酚反應與顆粒澱粉含量之關係

Table 5. The relationship between phenol reaction and amylose content in the F_2 of Chianung-Sen 11×Tainung 67.

Phenol reaction	Amylose content (%) 7	9	11	13	15	17	19	21	23	25	27	29	Total	Mean (%)	CV.	t-value
Positive reaction		2	2	6	14	31	22	46	33	18	4		180	19.0	0.19	0.03ns
Negative reaction			1	5	17	7	11	17	16	5	6		83	18.6	0.22	

綜合本節苯酚反應與膠體硬度及顆粒澱粉含量關係之探討可知，在嘉農秈11號×臺農67號組合之 F_2 集團中，秈稉兩羣之顆粒澱粉含量平均雖相同，但兩羣之膠體硬度之平均則不同，此是否暗示，同一顆粒澱粉含量基準之諸多個體中，其米粉膠體展流之程度可能不同。此等數據似可支持 Cagampang *et al* [6] 之同顆粒澱粉含量等級之不同稻品種中，其食用品質仍有差異存在之論點。

四、膠體硬度及顆粒澱粉含量與其他性狀之相關

相關係數係表示各性狀彼此間相互關係之程度，表現型相關乃性狀彼此間遺傳及環境綜合表現之相互關係，可供育種時選拔之參考；遺傳相關則爲控制各該性狀之遺傳因子的多效性效果或爲各因子間連鎖之結果；而環境相關則係環境之效果，可供吾人明瞭環境對該兩性狀表現之影響程度。而米粒之膠體硬度及顆粒澱粉含量係屬理化性狀，因此該兩性狀與其他產量構成性狀相關關係之探討，則有助吾人育種基礎知識之充實。故本研究分別估算兩 F_2 集團膠體硬度及顆粒澱粉含量與其他性狀之表現型相關，遺傳型相關及環境相關，其估算結果列於表 6。

表6. 水稻膠體硬度與其他性狀之表現型，遺傳型及環境相關

Table 6. Phenotypic (r_P), genotypic (r_G) and environmental (r_E) correlations between gel consistency and other characters in rice

Characters correlated	Chianung-Sen 11 × Tainung 67 r_P	r_G	r_E	Tainan 5 × Taichung (N) 1 r_P	r_G	r_E
Gel consistency and						
Amylose content	− 0.410**	− 0.446	− 0.203	− 0.539**	− 0.643	− 0.106
Panicle number	0.084	0.105	0.029	0.026	0.045	0.023
Spikelet number	− 0.059	− 0.030	− 0.172	0.062	0.163	0.014
% seed setting	0.047	0.180	− 0.161	0.059	0.453	0.037
1,000-grain weight	− 0.138*	0.129	0.203	0.054	0.103	0.011
Grain yield	− 0.053	0.113	0.172	0.109	0.173	0.065
Amylose content and						
Panicle number	− 0.050	0.013	− 0.230	− 0.054	0.231	− 0.315
Spikelet number	0.084	0.065	0.141	− 0.071	0.199	− 0.243
% seed setting	0.093	0.087	0.143	0.091	0.739	− 0.317
1,000-grain weight	− 0.045	0.085	− 0.304	0.047	− 0.425	0.515
Grain yield	0.050	0.066	0.001	− 0.015	0.270	− 0.331

**Significant at 1% level.
* Significant at 5% level.

綜覽表 6 可知，兩組合之米粒膠體硬度與顆粒澱粉含量均呈極顯著之負相關。而膠體硬度與其他產量性狀間之相關關係，則除嘉農秈11號×臺農67號組合內與千粒重成顯著之負相關外，餘均不顯著，亦即無相關關係。至於顆粒澱粉含量與其他產量性狀間之相關估值則均不顯著。此指出，稻米食用品質之選拔與稻穀產量之選拔須分別考慮，齊頭並行。

五、米粒膠體硬度與顆粒澱粉含量等性狀之遺傳率

遺傳率有兩種，一爲狹義，即遺傳成分中累加性變方佔總變方之比率；另爲廣義，乃顯性變方與累加性變方之和對總變方之比值。在育種選拔上，狹義遺傳率所蘊藏之訊息遠較廣義遺傳率者劍及而有意義。然本研究限於供試材料之關係，僅能進行廣義遺傳率之估算，其提供爲擬定育種計畫參考知識之確實性自較狹義者爲低，然，尚不失爲育種選拔之基礎知識之一，表 7 即爲本研究供試兩雜交組合米粒膠體硬度及顆粒澱粉含量等性狀之廣義遺傳率。

表7. 水稻膠體硬度等性狀之廣義遺傳率

Table 7. Broad sense heritability estimated from F_2 populations of rice crosses

Characters	Chianung-Sen 11 × Tainung 67	Tainan 5 × Taichung (N) 1
Gel consistency	89	93
Amylose content	82	72
Panicle number	62	23
Spikelet number	53	14
% seed setting	29	1
1,000-grain weight	84	27
Grain yield	64	32

由表 7 知，就雜交組合別言，嘉農秈11號×臺農67號組合中各性狀之廣義遺傳率概較臺南 5 號×臺中在來一號者爲高，而就個別性狀言，兩組合並以米粒之膠體硬度與顆粒澱粉含量之遺傳率較高，而以結實率之遺傳率最低，其他性狀則介於此兩者之間，惟兩組合各性狀遺傳率之大小並無一致之趨勢。

討　　論

多年來，由於稻作決策單位及育種學者之努力，臺灣水稻品種年年推陳出新，歲歲連登豐收，造成糧政當局莫大之困擾。惟過去之努力概僅注重稻穀產量之提高，而較忽視稻米品質之改良。而今世推時移，消費者已由「吃得飽」轉而希望「吃得好」。爲適應消費者由「量」的時代轉移至「質」的時代之須求，高品質水稻之育成乃當前水稻育種學者刻不容緩之急務。基此，農試所嘉義分所農藝系張主任萬來已針對秈稻食用品質展開研究[7]，筆者等早自1976年起針對此稻米品質問題進行文獻研討與綜論，深知秈粳稻雜交之育種在將來育種方向上可能具重要性，但食用品質互異之秈粳稻雜交後之膠體硬度及顆粒澱粉含量的遺傳知識則缺如，故本研究之目的即在探討此等食用品質之遺傳行爲。試驗結果顯示，兩組合 F_2 集團顆粒澱粉含量之頻度分布爲對稱之常態分布，此亦即兩組合本性狀符合典型的數量性狀之遺傳，此等結果恰與 Bollich and Webb[5] 研究中之 CI9444×PI215936 組合，Chang and Li[8] 及 Smorith *et al*[23] 等報告之顆粒澱粉含量高者對低者爲不完全顯性；而遺傳機制則除受一對主效因子 (major gene) 控制外，尚受若干微效因子 (minor gene) 或修飾因子 (modifier) 所左右的結果不同。而與 Bollich and Webb[5] 報告中 Nato×Asahi 組合 F_2 集

團顆粒澱粉含量之分離情形相類似。衆所周知，數量性狀遺傳行爲較爲複雜，且其表現易受環境左右，此點亦可由 Juliano[14] 論述的 IR 號品種顆粒澱粉含量之變域介 27—33%，亦即同一水稻品種之顆粒澱粉含量有 6 %之變異來印證。此等綜論似表示兩供試秈稉稻異型間雜交組合 F_2 顆粒澱粉含量之遺傳行爲應極不利育種家於 F_2 世代經由譜系法 (pedigree system) 行良質豐產水稻個體之選拔。惟吾人若仔細觀察表 3 則知，兩雜交組合 F_2 集團顆粒澱粉含量之分布與平均均恰落在低含量親本附近，且有相當多數之個體超越低含量親本作左方向之超越分離。此爲吾人所期望之契機。因爲環境雖可强烈影響水稻穀粒之顆粒澱粉含量，而產生如 IR 品種之 6 %變異，然就本研究所使用之兩組合言，即使選獲之 F_2 單株並非爲眞低顆粒澱粉含量者，但因顆粒澱粉含量之廣義遺傳率值很高，均在 80%(表 7)左右，故推論該獲選單株到後期世代時，其顆粒澱粉含量似仍應符合育種家之育種目標。

米粒膠體硬度之測定係新開發之米質檢定技術。本研究爲明瞭秈稉稻異型間雜交 F_2 集團之遺傳與變異，乃進一步測定上述兩雜交組合 F_2 集團各單株之米粒膠體硬度，結果發現所使用之秈稻親本均屬高膠體硬度；稉稻親本則爲低膠體硬度。並發現兩雜交組合 F_2 集團膠體硬度之頻度分布相當類似，並且均符合 3 高膠體硬度：1 低膠體硬度之單性雜種分離比，此結果與 Chang and Li[8] 在秈稻方面之研究結果相同。此亦即不管是秈稉異型間或秈稻同型間之雜交，米粒之膠體硬度均似係由一對主效獨立遺傳因子所控制且硬膠體對軟膠體呈完全顯性。因知，此兩秈稉異型稻間之雜交其米粒膠體硬度的遺傳行爲相當簡單，再加上兩組合膠體硬度之廣遺義傳率值亦達90%左右（表 7 ），凡此似指出本性狀行早期世代之單株選拔應屬有效。

黃[1] 在綜合檢討臺灣秈稻栽培面積之減少原因時指出，顆粒澱粉含量之測定因比較複雜，故對本省秈稻雜種分離早期世代的個體選拔，至今幫忙不多。而因爲米粒之顆粒澱粉含量與膠體硬度成負相關，且膠體硬度之測定簡單而迅速，爲替代顆粒澱粉含量定量之一可行辦法。故建議雜種初期世代使用膠體硬度之測定，以後成品系時，以顆粒澱粉含量再加以篩選比較合適。本研究獲得之綜合數據顯示，顆粒澱粉含量雖屬數量性狀，但兩 F_2 集團顆粒澱粉含量之分布則以低親本爲中心，且有相當多數個體向左超越低含量親本（表 3 ）；顆粒澱粉含量與膠體硬度成極顯著之負相關（表 6 ）；膠體硬度之遺傳行爲爲單一因子所控制，及此兩食用品質性狀之遺傳率相當高之事實，均支持黃[1] 提出之食用品質之篩選建議。即食用品質之育種選拔，初期龐大集團時行膠體硬度之測定；後期少數固定品系時行顆粒澱粉含量之分析，如此適期操作，應可滿足育種家經由秈稉稻異型間之雜交而選獲適合省民食性之品種。

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Improvement of Grain Quality in Rice

II. Genetical Studies on Gel Consistency and Amylose Content[1]

Yih-Chuan Kuo and Sung-Ching Hsieh[2]

Summary

Two eating qualities of rice, gel consistency and amylose content were studied genetically with the F_2 populations of the crosses Chianung-Sen 11 (*indica* type) × Tainung 67 (*japonica* type) and Tainan 5 (*japonica* type) ×Taichung (N) 1 (*indica* type). The results are summarized as follows:

1. The gel consistency in F_2 showed a bimodal distribution curve and skew to left pattern which is in agreement with a segregation ratio of 3 low gel consistency (hard) to 1 high gel consistency (soft). This indicates that the low gel consistency is controlled by a pair of dominant gene.
2. The amylose content in F_2 showed a normal distribution pattern indicating the polygenic nature of inheritance for this character. A considerable number of plants falls in the classes of low amylose (7%—17%) indicating that the chance of selecting low amylose individuals from the F_2 population is relatively great.
3. In the cross of *indica*×*japonica* rices, the progenies which showed the positive reaction to phenol staining (to rough rice) had a smaller mean value (36.6mm), while those with the negative phenol reaction and a larger mean value (41.7mm) of gel consistency. This indicated that the rice with positive phenol reaction (usually *indica* type) has the harder taste while that with negative phenol reaction (usually *japonica* type) has a softer taste when cooked.
4. A significant negative correlation between gel consistentcy and amylose content was observed. But they were not correlated with other agronomic characters.
5. The broad sense heritability values for gel consistency and amylose content were found to be very high being 90% and 77% respectively, indicating that selection for these two characters in the early generation is effective.

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1. Contribution No. 1077 from Taiwan Agricultural Research Institute.

2. Assistant Agronomist and Former Senior Agronomist respectively, TARI, Wufeng, Taichung Hsien, Taiwan 431, ROC.

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蘆筍莖頂培養之研究[1]

賴本智　陳良築　許淼淼　蔡新聲[2]

摘要：含有 0.1～0.5 mg/l Naphthaleneacetic acid (NAA), 0.1～0.5 mg/l Furfurylaminopurine (Kinetin) 及 2.5% Sucrose 之 Murashige *et al.* (1972)基本鹽類培養基可誘導蘆筍培養莖頂形成最多之芽及根。田間採取不同質地，不同位置之芽體培養顯示白色硬莖芽體之繁殖力優於綠色軟莖，距頂芽 1cm 以內之芽體又優於遠離頂芽者。不同品種間及品種內不同單株間莖頂培養誘導芽體繁殖之能力差異不大。莖頂培養大量繁殖後之試管苗，於11月份低溫下移植之成活率高於 5 月份高溫移植者。移植之最適苗齡爲培養後 3 個月之試管苗，配合低溫及適當保濕，其成活率可達87%。莖頂培養繁殖之植株，經與母株外型比較及根端細胞染色體檢定，均顯示與母株相同，證明莖頂培養是大量繁殖優良母株的最好方法之一。

蘆筍屬雌雄異株之常異交作物，田間產量的表現，雄株高於雌株 (14,16,19)，若能種植經選拔後高產之全雄株個體，則可大大提高產量 (3,4,5,13)；利用種子繁殖，將產生等量的雌雄個體，且株間具有不同的生產力，因此提高產量受到很大的限制 (15,20)，而質優高產的雄株雖可利用傳統分株法繁殖，但所得數量太少，且宿根頭易老化是其缺點 (26)，若能在短時間內大量繁殖優良雄株，則不但有助於收量的提高，且對採種事業上優良親本繁殖及利用，益處極大 (12,27)。利用莖頂培養的大量繁殖方法是達到此一目的最有效途徑 (13,18,19,20,22,27)。本研究之目的在找出蘆筍莖頂培養之最適培養基，培養體間之種種特性，莖頂培養植株之移植時間及移植苗齡，及經培養繁殖後植株的穩定性，以做爲今後大量繁殖優良雄株之參考。

材料與方法

利用種植於臺南改良場本場及義竹蘆筍中心的 UC157 及 UC309 等美國引進之優良蘆筍品種，選取田間優良株的嫩莖做爲大量繁殖研究之材料。每次採取之蘆筍嫩莖，經 10°C 低溫儲藏 5 小時後，以 10% Clorox (含 0.5% NaClO) 消毒 10分鐘，再以無菌水清洗數次後，切取大小約 1 mm之莖頂爲培養材料。

(一) 莖頂培養最適培養基之探討：

切取 UC157 及 UC309 兩種品種田間嫩筍的芽體，培養於含有 0.3 mg/l 及 0.1 mg/l kinetin 之 Murashige *et al.* (1972) 基本鹽類培養基上，經 10 星期生長，切取發育良好大小約 1mm 的莖頂，培養於表 1 及表 2 所列含有不同 auxin 或 cytokinin 濃度組合的 Murashige *et al.* (1972) 基本鹽類培養基上，以找出最適莖頂培養基。

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1. 臺灣省農業試驗所研究報告第1078號。本試驗承臺灣區洋菇、蘆筍試驗研究審議小組及中正科技講座補助，試驗材料，承臺南區農業改良場提供，文承劉博士大江斧正，謹此申謝。

2. 本所農藝系助理研究員、助理、研究助理及研究員。臺灣省　臺中縣　霧峰鄉。

（二）嫩筍上不同質地、不同部位芽體繁殖力差異之研究：

將田間採得之 UC309 嫩筍，區分爲白色硬莖及綠色軟莖二部分，分別採取距頂芽 1 cm 內及 1～8 cm 間之芽體培養於含有 0.3 mg/l NAA 及 0.1 mg/l kinetin 之 Murashige *et al.* (1972) 基本鹽類培養基上，以測定不同質地、不同部位芽體經由莖頂培養大量繁殖之能力。UC157 及 UC309 二品種間同時標示品種內之不同單株，以測定品種間及品種內單株間芽體繁殖力之差異性。

培養基之 pH 值均經調整爲 5.7±0.1，以 121 °C, 15 lb/in^2 之高溫高壓殺菌 15 分鐘。接種後之培養體置於 27±1°C 之恆溫，以 1,500 lux 之光强，每日行 16 小時之照射培養，誘導新芽成長及發根，並調查形成的芽數與根數。

（三）莖頂培養試管苗之移植時間及移植苗齡對成活率之影響研究：

莖頂培養移植之幼苗爲 UC157 品種第 2 單株，莖頂培養於 0.3 mg/l NAA 及 0.1 mg/l kinetin 之 Murashige *et al.* (1972) 基本鹽類培養基上，將培養 4 個月大之幼苗於冬天及夏天分別移植到盛有泥炭土之水稻育苗箱上，每日早晚噴霧 2 次，每次10秒鐘，並隨時觀察及調整泥炭土之濕度，1 個月後調查移植成活率。另以相同材料之莖頂經培養 1－5 個月後，在冬天移植於同樣盛有泥炭土之水稻育苗箱上，並注意濕度之保持，移植 1 個月、2 個月及 3 個月後，分別調查其成活率，並比較各苗齡之成活率。

（四）莖頂培養所得植株染色體數目的檢定：

切取試管繁殖之蘆筍苗根尖約 0.5 公分，先經 0.002 M 之 8-hydroquinoline 處理 3 小時後，以 ethanol：acetic acid＝3：1 固定液固定 12 小時，若需保存則移至 70% 酒精置於 5 °C 冰箱中，鏡檢當日先將固定之根尖置於 60° C 之 1 N HCl 溶液中處理10分鐘，染色及再軟化的處理是先以feulgen 染色液處理 2 小時後，再以 5 % pectinase 處理 2 小時，最後以 aceto-carmine 壓饋製片，於光學顯微鏡下檢查染色體的數目 (1)。

結 果

（一）莖頂培養最適培養基之探討：

表1. 不同 Cytokinin 濃度對蘆筍莖頂培養10週後長芽與發根之影響。

Table 1. Effect of cytokinin on shoot and root formation from asparagus shoot tip culture for ten weeks (cv. UC 157 and UC 309)*

Treatment	Conc. (mg/l) of			UC 157**		UC 309**	
	NAA	Kinetin	BA	No. of shoot	No. of root	No. of shoot	No. of root
1(ck)	0	0	0	3.15d	7.05b	3.45c	5.52c
2	0.3	0	0	4.39d	11.77b	3.75c	5.25c
3	0.3	0.1	0	9.75b	20.23a	9.09ab	12.88a
4	0.3	0.5	0	13.45a	9.77b	11.13a	11.42ab
5	0.3	1.0	0	8.62b	8.89b	11.79a	6.13bc
6	0.3	5.0	0	6.04c	0.11c	10.21ab	0.00d
7	0.3	10.0	0	4.18cd	0.18c	8.65ab	0.07d
8	0.3	0	1.0	3.77d	0.18c	7.81abc	0.00d

*Basal media：Murashige *et al.* (1972) salts.

**Mean (20—30 plants per treatment) separation in column by Duncan's multiple range test, 5% level.

表1、2爲UC 157及UC 309之試管苗莖頂培養於不同濃度之cytokinin及auxin，經生長10個星期後，芽體形成數目及根發育之結果。

表1資料顯示不含植物荷爾蒙之基本 Murashige *et al.* (1972) 培養基雖可使一個培養芽體變成三個，且有相當數目的根生成，但培植結果却遠不如加定量 NAA 或 kinetin 之培養基，在NAA固定於0.3 mg/l之情形下，kinetin以 0.1~0.5 mg/l 之濃度對促進長芽及生根的效果較好。1.0 mg/l 以上之 kinetin 雖對芽體形成不會造成太大影響，但對根的形成却稍有抑制作用。在 5.0 mg/l 以上則顯著影響根的形成及發育，1.0 mg/l 之 BA 對長芽不但效果不佳，而且嚴重影響根的形成，其作用和 10 mg/l kinetin 極爲相似，兩受測品種 UC 157 及 UC 309 對不同濃度之反應極爲一致。

表2資料則爲 kinetin 濃度固定於 0.1 mg/l 下，不同濃度之 NAA 對蘆筍莖頂培養形成芽體及發根所造成的影響。從芽的形成數目觀之，似乎以 0~1.0 mg/l 之 NAA 最佳，過高濃度（超過5 mg/l）之 NAA，抑制芽體之形成，根的形成數目則稍可忍受較高濃度之NAA（如 5 mg/l），就生根長芽二者都有利的情形而言，則以0.1~0.5 mg/l NAA 之濃度最適，而 1 mg/l之 IAA 效果不錯，NAA 與 IAA 何者較佳有待更進一步研究。

表 2. 不同 auxin 濃度對蘆筍莖頂培養10週後長芽與發根之影響。

Table 2. Effect of auxin on shoot and root formation from asparagus shoot tip culture for ten weeks (cv. UC 157 and UC 309)*

Treatment	Conc. (mg/l) of			UC 157**		UC 309**	
	NAA	Kinetin	IAA	No. of shoot	No. of root	No. of shoot	No. of root
1	0	0	0	3.15[cd]	7.05[d]	3.54[b]	5.52[d]
2	0	0.1	0	7.37[ab]	23.96[ab]	8.64[a]	11.41[cd]
3	0.1	0.1	0	6.67[ab]	25.50[a]	6.05[ab]	10.35[cd]
4	0.5	0.1	0	6.50[ab]	23.38[ab]	5.09[ab]	22.18[ab]
5	1.0	0.1	0	5.21[bc]	18.00[c]	6.23[ab]	18.66[ab]
6	5.0	0.1	0	2.08[cd]	8.18[d]	3.79[b]	15.42[bc]
7	10.0	0.1	0	1.62[d]	3.43[d]	0.54[c]	6.09[d]
8	0	0.1	1.0	8.59[a]	19.42[bc]	4.09[b]	9.91[cd]

*Basal media: Murashige *et al.* (1972) salts.

**Mean (20—30 plants per treatment) separation in column by Duncan's multiple range test, 5% level.

綜合表1，表2之結果得知蘆筍莖頂培養大量繁殖之最佳培養基爲 0.1~0.5 mg/l kinetin及 0.1~0.5 mg/l NAA 之 Murashige *et al.* (1972) 基本鹽類培養基。

（二）嫩筍上不同質地，不同部位芽體繁殖力差異之研究：

表3爲採自不同質地、不同部位之 UC 309 蘆筍芽體所具不同繁殖力之差異。資料顯示質地方面，以白色硬莖芽體所具之繁殖力較佳，平均每個芽體經8星期的培養約可形成15個以上之新芽，而綠色嫩莖則又依不同部位之芽體而有極大之差異。距頂芽 1 cm 以內之芽體幾乎具有和白色硬莖芽相同之繁殖力，而距頂芽在 1 cm 以上之芽體則繁殖力顯著減少，雖經8星期培養亦只得2.7個新芽而已。根的形成方面，二種質地及不同部位之芽體差異不大。圖1爲表3之芽體經20個星期之生長形成

新芽體之數目，除了綠色嫩莖之遠離莖頂芽（距頂芽 1～8 cm）具較差之長芽能力外，其餘三種芽體都可形成 30～40 左右之新芽體。

表3. 田間嫩筍不同質地，不同位置之芽體培養8週後之芽數及根數。

Table 3. Growing ability of buds from different portion of asparagus spears (taken from field) after eight weeks in culture* (cv. UC 309)

Kind of spear	Bud position on spears	No. of shoot**	No. of root**
Hard (white color)	Within 1cm from apical bud	19.1[a]	6.0[a]
	1—8cm from apical bud	15.3[a]	5.9[a]
Soft (green color)	Within 1cm from apical bud	12.6[a]	11.2[a]
	1—8cm from apical bud	2.7[b]	9.0[a]

*Basal media : Murashige *et al.* (1972) salts with 0.3 mg/l NAA and 0.1 mg/l kinetin.

**Mean (20—30 plants per treatment) separation in column by Duncan's multiple range test, 5% level.

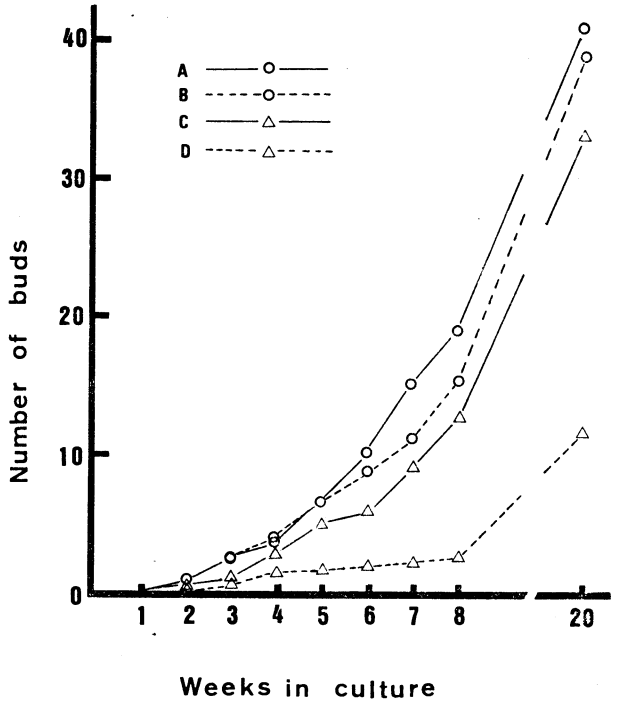

圖1. 田間嫩筍不同質地，不同位置芽體培養後之生長能力。

Fig. 1 Growing ability of buds from different portion of asparagus spears taken from field. Bud position :

A - within 1cm from apical bud of hard spear.

B - 1—8cm from apical bud of hard spear.

C - within 1cm from apical bud of soft spear.

D - 1—8cm from apical bud of soft spear.

表四顯示田間標示 UC 157 及 UC 309 二品種間及品種內各單株間距頂芽 1 cm 以內之芽體經12週培養後形成之芽數及根數。芽數方面，各單株間之差異不大，未達顯著水準，但形成的根數，差異可達顯著水準。蘆筍各單株間之芽體是否具有不同的繁殖力，以表 4 的資料要下結論尚言之過早，詳細結果正進一步研究中。

表4. 不同植株之蘆筍芽體培養12週後之芽數及根數。

Table 4. The growing ability of buds taken from different plant of asparagus after 12 weeks in culture

Variety and plant No.	No. of. shoot*	No. of root*
UC 157—1	12.4[a]	7.6[b]
2—1**	19.5[a]	10.4[ab]
2—2	18.1[a]	6.1[b]
3	13.7[a]	14.4[a]
4	14.4[a]	6.7[b]
UC 309—1—1	9.2[a]	4.9[c]
1—2	10.0[a]	4.0[c]
2—1	11.9[a]	9.7[ab]
2—2	8.9[a]	10.7[a]
3—1	11.1[a]	5.8[bc]
3—2	9.9[a]	6.8[abc]
4—1	14.1[a]	6.9[abc]
4—2	11.2[a]	5.5[bc]
4—3	11.9[a]	8.1[abc]

* Mean (20—30 plants per treatment) separation in column by Duncan's multiple range test, 5% level.

** 2—1 : representing buds taken from plant No. 2, first spear.

(三) 莖頂培養試管苗之移植時間及移植苗齡與成活率之關係：

表 5 爲不同季節移植蘆筍莖頂培養苗對其成活率之影響。資料顯示 UC 157 4 個月大之試管苗，冬天 (11~12月份) 移植之成活率爲 55.8%，約高出夏季 (5 ~ 6 月份) 移植之 25.8%一倍。

表5. 移植時間對蘆筍莖頂培養苗成活率之影響。

Table 5. Influence of transplanting date on the survival ability of test tube asparagus seedlings*

Date of transplanting	Total plants used	No. of plants survived	Percent of survival
November 26	120	67	55.8
May 1	120	31	25.8

*Test tube seedling obtained from shoot tip of UC 157 cultured on the Murashige *et al.* (1972) basal media with 0.3 mg/l NAA and 0.1 mg/l kinetin for 4 months.

表6為 UC 157 莖頂培養不同月齡移植後之成活率。培養時間愈短形成之芽數及硬根數愈少，雖然形成的芽數及硬根數以培養5個月後之幼苗最多，但成活率却以培養3個月幼苗之66.3%（移植1個月後調查）最高，繼續觀察到第3個月後移植成活率可提高至86.5%，4月齡為 59.2% 次之，5月齡、2月齡及1月齡又分別為54.2、53.9及52.7%。3月齡之幼苗具適量之芽數及硬根數，生育最為旺盛，又無黃化及老化之現象，故移植成活率最佳。蘆筍為多年生宿根作物，莖頂培養繁殖過程中，嫩莖基部往往會形成小根盤，移植初期根部吸收能力慢，嫩莖及嫩葉易於枯萎，以致被錯認為死亡，但2～3個月後，可由根盤長出新芽，這是移植三個月後成活率反而升高的原因。

表6. 不同月齡莖頂培養苗生長情形及移植之成活率。

Table 6. The growth condition and survival ability of asparagus shoot tip after several months in culture*

Months in culture	No. of shoot forming	No. of hard root forming	No. of plants trans-planting	No. of plants survival			Percent of survival		
				A**	B**	C**	A**	B**	C**
1	5.58c	0.26c	112	23	47	59	20.5c	41.9c	52.7b
2	8.54b	6.20b	76	26	34	41	34.2bc	44.7bc	53.9b
3	10.91ab	8.55a	104	69	84	90	66.3a	80.8a	86.5a
4	11.50a	8.70a	120	67	68	71	55.8a	56.7b	59.2b
5	12.10a	9.59a	107	41	58	58	38.3b	54.2bc	54.2b

* Mean (80—100 plants per treatment) separation in column by Duncan's multiple range test, 5% level.

** A, B, C : Data obtained from seedling have been transplanted into peat moss for 1, 2 and 3 month respectively. Seedling were transplanted on November.

(四) 莖頂培養植株染色體數目之檢定

經由莖頂培養繁殖的植株由肉眼觀察，發現其外部形態與母株完全一致，且根尖細胞的染色體經檢查後，也證實全為正常的二倍體（2N＝20），故莖頂培養後代植株具有高度的遺傳穩定性是不容懷疑的。

討　論

利用莖頂培養大量繁殖蘆筍植株之研究，許多文獻均曾提及 [20,23,24,25,26]。在莖頂培養過程中，長芽及發根能力，極易受到下列因素影響，如培養基中 cytokinin 及 auxin 的種類與濃度 [18,23,27]、培植體的來源、位置、種類及大小等 [22,23,26,27]。有關蘆筍莖頂培養，培養基中 cytokinin 及 auxin 之種類及適當含量，許多學者看法不同 [18,23,27]，如 Yang 等氏認為 0.1 mg/l NAA 配合 0.1 mg/l kinetin 最適合莖頂繁殖 [23,24]，Murashige 等氏則使用 0.3 mg/l NAA 配合 0.1 mg/l kinetin [18]，但 Harada 氏却認為 1.0 mg/l NAA 及 0.1 mg/l zeatin 最適合莖頂繁殖 [11]。本試驗得知含有 0.1～0.5 mg/l NAA 及 0.1～0.5 mg/l kinetin 之 Murashige *et al.* (1972) 基本鹽類培養基最適合蘆筍莖頂大量繁殖之用。

適量的 kinetin 可增加嫩莖與根之誘導，同時減少嫩莖基部癒傷組織之形成，濃度太高或太低不但不利於發根，且會對培植體移植時的成活率造成重大影響 [18,23]，一般 kinetin 之效果優於 BA，故大多數學者培養蘆筍莖頂，均添加 kinetin 於培養基中 [18,25,26,27]，此與 Harada (1973) 蘆筍莖頂培養之結果相異，他認為在 NAA 配合下，BA 較 kinetin 易於誘導長芽及發根，添加 zeatin 之誘導效果更高。

0.1 mg/l～0.5 mg/l NAA 配合 0.1 mg/l kinetin 之濃度有利於發根，而且不會抑制芽體形成，濃度過高則不但減少形成的芽數及根數，同時會造成癒傷組織之大量形成。Yang (1974) 發現 UC 500 W 品種的芽體培養於 0.1 mg/l NAA 配合 0.1 mg/l kinetin 之組合，可誘導芽體形成最多的芽數及根數，若提高 NAA 濃度至 0.3 mg/l，可稍爲抑制芽體之生長及發根能力，同時增加癒傷組織之形成，因而減少培養苗之成活率 [18,23]，本研究發現影響試管苗移植成活率之主要因子爲移植時之溫度及濕度，NAA 雖提高至 0.5 mg/l，對成活率尙不致造成影響。

田間白色硬莖及綠色軟莖嫩筍上不同位置之芽體經 8 週培養後，顯示愈近頂端之芽體繁殖力愈佳。且白色硬莖之芽體培養後較易長芽，而綠色軟莖之芽體則易發根，此種現象隨着培養時間延長，仍有相同之趨勢，故田間嫩筍之大量繁殖以採自近頂芽的芽體可得較佳之繁殖力。

蘆筍莖頂培養植株移植時間以冬季較適合，可能是冬季的低溫減少了移植幼苗之蒸散作用，及嫩莖枯萎之速度，因而獲致較佳之移植成活率 [25]。同時，移植後泥炭土濕度之調整也頗爲重要，據 Yang (1974) 以 Jiffy-7 泥炭盆罩以噴霧裝置控制適當濕度可得極高之移植成活率。莖頂培養 3 個月齡之幼苗，移植後成活率最高，此結果與 Yang (1977) 報導培養 3 個月之幼苗擁有最適量之芽數及根數，具有最佳活力，可得最高成活率相吻合 [25,27]。

蘆筍莖頂較其細胞或癒傷組織擁有更高的發育自主能力 [19]，經培養後極易長成形質穩定的多數芽體，早爲許多學者所發現 [1,17]，不僅外部形態和內部構造殊少變異，而且後代植株根尖細胞的染色體數目也極爲一致，故蘆筍莖頂培養確爲保存優良親本且短時間內可大量繁殖之最有效途徑 [18,23]。

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Studies on Shoot Tip Culture of Asparagus[1]

Pen-Chih Lai, Liang-Jwu Chen, Meau-Meau Hsu and Hsin-Sheng Tsay[2]

Summary

Asparagus (*Asparagus officinalis* L.) shoot tips of UC157 and UC309 were cultured on Murashige *et al.* (1972) basal medium supplemented with various amounts of auxin and cytokinin. It was found that the basal medium added with 0.3 mg/l NAA, 0.1mg/l kinetin and 2.5% sucrose could provide the best result in producing complete plantlets from the excised shoot tips.

The growth and differentiating ability of buds from the white hard spear (cv. UC309) was superior to that from the green soft spear. Furthermore, bud section within 1 cm from the shoot tip showed the highest growth vigor and differentiating rate than the lower bud sections. No difference in the ability of shoot production was found among individual plants of the same variety or among different varieties.

Survival rate of asparagus seedlings transplanted from test tube to the greenhouse was higher when performed under low temperature (November) than under high temperature (May). Seedling age of three-month in test tube was considered the most suitable for transplanting. When high humidity was maintained, survival rate as high as 87% could be obtained.

Cytological examination on the root tips of asparagus seedlings originated from shoot tips or lateral buds of spear culture showed diploid chromosome number of 2N=20. No polyploid plants were found. Those results indicated that this propagating method can effectively maintain the nature of mother plants.

1. Contribution No. 1078 from the Taiwan Agricultural Research Institute.
2. Assistant Agronomist, Research Assistant, Assistant and Senior Agronomist, respectively of the Department of Agronomy, TARI. Wufeng, Taichung Hsien, Taiwan 431, ROC.

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檬果腋花穗之誘引[1]

許 仁 宏[2]

摘要 腋花芽分化大致與頂芽分化相似，只是體積較小，不到頂芽的½。從剪穗到初步分化成花芽約需12—20天。

海頓最容易形成花穗，凱特其次，愛文較差。

不管剪掉當年生枝條，去年生枝條，甚至前年生枝條，都可以長出花穗者，只是愈老的枝條其長穗的活力愈低，此可作爲以後機械修剪的參考資料。

直徑與每枝條平均穗數呈正相關（r＝0.21**），但與穗長無關；角度與穗長呈負相關（r＝－0.30**），但與每枝條平均穗數無關。

檬果（*Mangifera indica* L.）摘去頂花穗誘引腋花穗的形成，在實際利用上有兩個方向：一是調節產期，增加收益；一是避開天災（如寒害），確保生產。調節產期應用方面，本省的實例爲南投縣水里鄉上安村的檬果園，利用腋花穗誘引配合晚生品種凱特，以及該地冷涼氣候，使果實在九月末到十月中收穫，此時全省檬果稀少，因而商品價值提高。但農民在使用這個方法時，發現有時去花穗後，並不會形成腋花穗，而却長出葉梢，此種原因尚待進一步探討。避開寒害等天災，以確保產量，國外有以色列[(7)]與印度[(15)]的實例，但本省亦尚無報告。

本試驗在探討剪穗誘引腋花穗形成的一般反應，以作爲今後農民使用此法的參考。

材料與方法

自民國六十九年十二月十九日起，分三次處理。每次選擇76枝生育狀況相似，已開小花約佔全花穗½—⅔的當年生枝條。由枝條頂端（花穗基部）下方5公分處剪掉，其中36枝枝條各在第0、3、6、9、12、15、20、25、30天剪下4枝條，固定最上端腋芽切片觀察，切片處理方法與前報告相同[(2)]。剩下40枝枝條，於修剪後第50天計算腋花穗形成百分率，平均穗數與穗長。調查探討枝條直徑、角度、修剪長短以及剪穗前花穗長度與腋花穗形成率的相互關係。處理日期與品種列於表1，氣象資料列於表2。

表1. 試驗時期與使用的品種和處理

Table 1. Time, varieties and treatments used in the experiment

時期 Time	品種 Varieties	處理 Treatments
69年12月19日 —70年2月6日 Dec. 19th, 1980 —Feb. 6th, 1981	海頓 Haden	詳見材料與方法文中敍述 76 branches with panicles about 30 cm long and 50% to 75% of their flower blooming or bloomed were selected. The

1.臺灣省農業試驗所 研究報告第1079號。

2.鳳山熱帶園藝試驗分所果樹系助理研究員。臺灣省 高雄縣 鳳山市。

		upper 5 cm of these branches were pruned. Lateral buds at the top of four branches selected randomly were fixed and paraffin sectioned at 0, 3rd, 6th, 9th, 12th, 15th, 20th, 25th, and 30th day. The remaing 40 branches were investigated for percentage of flower formed, number and length of the panicles at 50th day after pruning.
70年1月1日 —70年3月16日 Jan. 1st , 1981 —Mar. 16th, 1981	海　頓 Haden	同　上 —do—
70年2月19日 —70年4月9日 Feb. 19th, 1981 —Apr. 9th, 1981	海　頓 愛　文 凱　特 Haden Irwin Keitt	同　上 —do—

表2. 試驗期間果園的溫度和雨量資料

Table 2. Climatic informations throughout the experiment

時　期 Period	溫　度 Temperature		雨　量 Precipitation (mm)
	Avg (°C)	Min (°C)	
Dec. 19th, 1980 —Feb. 6th, 1981	17.5	11.9	2.2
Jan. 1st , 1981 —Mar. 16th, 1981	20.3	16.2	0.7
Feb. 19th, 1981 —Apr. 9th, 1981	22.6	17.9	229.7

結　　果

(一) 腋花芽的分化過程

海頓檬果腋花芽分化的過程，大略分爲四個階段（圖1），第一階段芽體在1厘米以下，鱗葉扁平環抱半圓形的莖頂。第二階段側芽稍膨大，鱗葉有往上直立的趨向，莖頂體積變大，由四周往外分生側生小花穗原始組織。第三階段側生小花穗原始組織已長出，芽體長度在 1.5厘米以上。第四階段芽長在3厘米以上，鱗葉直立，已爲很明顯的花芽。

(二) 不同剪穗期對腋花芽分化速度與花穗形成率的影響

表3爲海頓檬果在三個時期剪穗後，其腋花芽分化程度與長度的比較，69年12月19日剪穗的處理到20日後迅速分化（1%水準顯著）。其芽體也極顯著地增長。70年1月26日剪穗的處理在12日即達第二階段以上分化，15日有極顯著的差異，長度在15日才極顯著地增長。70年2月19日的處理在12日亦分化至第二階段，採芽日期間芽體分化與芽長的差異在30日達5%水準顯著，剪穗期之間分化速度差異不顯著，芽長則有極顯著的差異。剪穗50天後調查側花穗形成的比率很高，都在90%以上，但二月十九日剪穗的處理較低，花穗數也有相同趨向，平均穗長則無差異（表4）。

(三) 不同品種間腋花芽分化速度與花穗形成率的比較

表5爲海頓、愛文、凱特三品種分化期與腋芽長度的比較，海頓在剪穗後12日即達第二階段，但處理間分化期與芽長的差異，在第30天才達極顯著；愛文在第20天才分化到第二階段；採芽處理間差異均不顯著；凱特在第15天可分化到第二階段，採芽處理間差異亦不顯著。品種間腋芽分化有極顯著差異，海頓遠較愛文與凱特分化迅速；芽長間無差異。

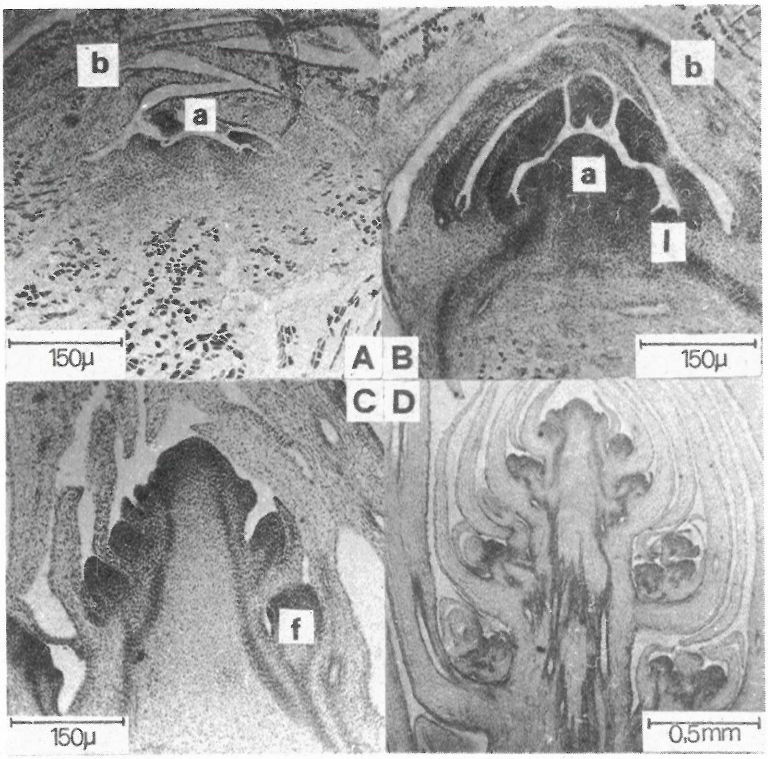

圖1.檬果腋花芽分化過程中四階段內部解剖構造圖 a：莖頂，b：鱗葉，f：花原組織，l：側芽

Fig. 1. Photomicrographs showing the floral development of an axillary bud in Haden mango. a : apex, b : bud scales, f : floral primordia, l : lateral bud.

表3. 海頓檬果在不同剪穗期剪穗後，腋花芽分化程度與長度的比較

Table 3. Axillary floral bud differentiation of Haden mango as affected by de-blossoming dates.

Treatment (days)	De-blossoming dates		
	Dec. 19th, 1980	Jan. 1st, 1981	Feb. 19th, 1981
0	1.0^z (0.97)^y	1.0(0.75)	—
3	1.0 (0.99)	1.0(1.05)	1.0(0.71)
6	1.0 (1.10)	1.5(0.62)	1.5(0.99)
9	1.0 (0.81)	—	1.5(1.37)
12	1.5 (1.10)	2.0(1.20)	2.0(1.31)
15	1.0 (0.78)	3.0(2.14)	2.5(1.19)
20	3.5 (3.72)	4.0(3.82)	2.5(1.67)
25	2.5 (1.71)	—	3.0(1.77)
30	4.0 (7.00)	4.0(5.38)	4.0(2.69)

z : mean value of the 4 differentiating stages.

y : bud length ; mm

LSD between treatments 0.84** (0.87)**.

LSD between de-blossoming dates N. S. (0.51*)

表4. 不同剪穗期剪穗50天後腋花芽形成百分率，每枝條花穗數及花穗長度的比較（40枝條平均）

Table 4. Inflences of de-blossoming dates on axillary flower formation, number and length of panicles in Haden mango 50 days after pruning (Average of 40 branches)

Treatment	Axillary flower formed (%)	No. of panicles per branch	Average length (cm)
Dec. 19th, 1980	100.0	3.4	10.4
Jan. 1st , 1981	97.5	3.0	9.3
Feb. 19th, 1981	90.0	2.0	10.6
LSD		1.2*	N. S.

剪穗50天後，海頓所形成腋花的比率最高，達90%，其他兩個品種相差很大，在20%以上，但花穗數與平均穗長却沒有差異（表6）。

表5. 不同品種腋花芽分化速度與長度間的比較

Table 5. Axillary floral bud differentiation of mango as affected by different varieties.

Treatments (days)	Varieties		
	Haden	Irwin	Keitt
0	—	—	—
3	1.0[z] (0.71)[y]	1.0(0.78)	1.0(0.55)
6	1.5 (0.99)	1.0(0.45)	1.0(0.63)
9	1.5 (1.37)	1.0(1.05)	1.0(0.73)
12	2.0 (1.31)	1.0(0.75)	—
15	2.5 (1.19)	1.5(1.03)	2.0(1.13)
25	3.0 (1.77)	2.5(2.08)	2.5(1.44)
30	4.0 (2.69)	2.0(1.25)	1.5(1.21)

z, y : See table 3

LSD between treatments 0.67** (0.56)**

LSD between varieties 0.39* (N. S.)

表6. 不同品種剪穗50天後腋花穗形成百分率、每枝條花穗數以及花穗長度的比較（70.2.19剪穗）

Table 6. Responses of different mango varieties to de-blossoming treatment in axillary flower formation, number and length of panicles 50 days after pruning (de-blossomed on Feb. 19th, 1981) .

Varieties	Axillary flower formed (%)	No. of panicls per branch	Average length (cm)
Haden	90.0	2.0	10.6
Irwin	60.0	1.4	9.8
Keitt	70.0	1.2	9.9
LSD		N. S.	N. S.

（四）植株狀況與腋花芽形成的關係

剪穗前花穗的長短（5公分到30公分）與腋花穗形成數目有關係，但只有在花穗長5公分時剪穗，所形成的腋花穗數較多（平均每枝條5穗），其餘長度間差異不大。修剪枝條的長度與腋花穗形成之間有密切的關係，一般而言，枝條修剪愈長，花穗形成的比率愈低（表7），但平均穗長則無固定趣向可循。

枝條直徑與穗數呈正相關($\gamma=0.21^{**}$)，但與穗長無關。枝條角度與穗長呈負相關($\gamma=-0.30^{**}$)，但與穗數無關。

只摘花穗的枝條，其平均腋花穗孕育時間較剪穗枝條快約5天。

表7. 不同剪枝長度對腋花穗形成數目與花穗長度的影響（每處理20枝條平均數）

Table 7. Effects of pruning length on the formation of axillary panicle in mango. (Average of 20 branches each)[z]

Treatment (branch length)	Average panicles per branch	Average panicle length (cm)
5 cm	4.3	6.2
15 cm	2.5	7.8
30 cm	2.3	9.8
40 cm	1.5	7.0
LSD	0.7*	1.6*

z : Branches with panicles 30 cm long and 50% to 75% of their flowers blooming or bloomed.

圖2. 凱特檬果在摘花處理後，部分枝條同時長出新梢與花穗

Fig. 2. Sprouting shoots and inflorescences arise simultaneously from a branch of Keitt mango after de-blossoming treatment.

討　論

檬果腋花芽的分化過程和頂花芽[2]相似，但體積較小；外部形態最大的不同在於前期鱗葉呈扁平地環抱。分化時間海頓品種最快爲6天，但一般要12天；愛文與凱特的分化速度較海頓慢，大約要15到20天（表5）。此結果與 Reece 等人[12]與 Alcala 與 Pedro[3] 的結果相近，至於植株間分化時間差異可能是植株、枝條的狀況、環剝與否及環境的差異所影響[12]。

在一月和二月剪穗的處理，腋花芽分化的速度較十二月剪穗者快，此結果與頂花芽的分化相類似[2]。芽長在不同日期的起伏不定，推想是因爲植物體本身的狀況所引起。腋花穗的形成率可能與氣溫的高低有關，二月剪穗的處理因氣溫漸漸升高，花穗形成率也降低。但植株因結實而消耗大量養分的因素，也應考慮在內。短暫的雨量沒有造成分化速度加快，或穗長增加，可能是樹體的緩衝作用或雨量不够充沛所致。

檬果品種對剪穗促成腋花穗有不同的反應，其差距由100%到16%[14]。本試驗的結果顯示海頓品種是一種很容易長出腋花芽的品種，而愛文與凱特則較差（表6），凱特有時腋花芽與腋枝同時長出（圖2），此種現象在營養或開花激素觀點上[13]很難解釋。由於海頓開花較早，結果率較低，去穗後腋花穗形成的百分率高，因此國外已有人應用於實際增產上[7,15]，但這可能只限於環境不適的地區或年份，如果在環境適宜的地區或年份，則無增產的效用[1]。

爲了降低果園管理的成本，以機械來修剪果樹已在世界各地發展，如以色列的矮性桃[6]，匈牙利的蘋果[8]，美國的蘋果[5]、來母與檸檬[17]以及澳洲的晚侖西亞甜橙[4]等。檬果花穗通常由當年生枝梢抽出[9,16]，而且分化時間很短[2]，所以很適合機械修剪。表7的結果配合印度的資料[10,11]，可供本省檬果機械與人工修剪參考。

只摘花穗枝條的分化速度較快，可能與頂芽優勢（花穗旁邊的芽與花穗下方5公分的腋芽比較）或營養狀況有關，在實際利用上有其價值。

枝條直徑與穗數呈極顯著正相關，但與穗長無關，可能因蓄積與製造營養份的能力差別所造成。角度愈小，穗長愈長的結果和下垂枝條碳氮比較高的傳統觀念相吻合，但進一步的生理研究應可更合理地解釋。

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Axillary Panicle Induction in Mango (*Mangifera indica* L.)[1]

Zen-Hong Shu[2]

Summary

There are two main advantages in the induction of axillary panicles of mango. The first is to escape from bad weather condition and the other to produce off-season fruits.

To realize the respones to the induction in commercial varieties, experiments were conducted to understand to anatomical changes of buds, the influences of de-blossoming dates, the effects of different varieties and the effects of plant conditions.

Haden is identified to be the most panicle-inducible variety. It takes twelve to twenty days from pruning to the initiation of floral bud. Higher temperature and fruit loading are suggested to be the reasons for the inability in panicle induction.

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1. Contribution No. 1079 from Taiwan Agricultural Research Institute.
2. Assistant Horticulturist, Department of Tropical Fruits, Fengshan Tropical Horticultural Experiment Station, Fengshan, Kaohsiung, Taiwan 830, ROC.

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Variation in Fruit Characters between Normal- and Shrivelled-seed Lychee Varieties[1]

Chung-ruey Yen[2]

Abstract Variation of fruit characters within and among trees were studied in two shrivelled-seed varieties of "Sah Keng" and "Kang Wei" and the most widely cultivated normal-seed variety "Hak Ip". Analysis of variance showed that the variation among trees contributed more to the total variability than that within tree. Analysis also indicated that the variation among locations was much greater than that of within and among trees, in "Hak Ip" variety.

In general, fruit length, fruit diameter, fruit weight, shell weight, and aril weight were not significantly different within tree. The protuberance of the shell, aril color, percentage of shrivelled seeds and ratio of aril weighs in fruit were not significantly different both within and among trees in most locations. The variation of soluble solids, flavor and seed size were different depending on the varieties and locations.

The shrivelled seed of "Sah Keng", "Kang Wei" and "Hak Ip" were 36%, 26%, and 0%, respectively. Eating quality of shrivelled-seed fruits were superior to normal-seed fruits in smaller seed size and higher aril ratio. The fruit diameter, fruit Weight, and shell weight were highly correlated to seed size in two shrivelled-seed varieties, but not in normal-seed variety. The fruit size and fruit weight of normal-seed variety were larger and heavier than shrivelled-seed fruit, however, the soluble solids was not significantly different.

The lychee (*Litchi chinensis*, Sonn.) is a subtropical evergreen tree and believed to be indigenous to Southern China where it has been cultivated for thousands of years. The cultivation now is extended to India, South Africa, Australia, Hawaii and Florida of USA [2,13]. Due to variation and mutation of seedlings and buds, there are many varieties of lychee in Southern China [1,2,13]. Groff (1921) listed 49 varieties of lychee from the province of Kwangtung [1]. Huang (1966) described 18 important varieties in Kwangtung and Kwangsi. He also listed the fruit characters of 14 varieties in Taiwan

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1. Contribution No. 1080 from the Taiwan Agricultural Research Institute.
2. Assistant Horticulturist, Department of Horticulture. Chai-yi Agricultural Experiment Station, TARI. Chiayi , Taiwan 600, ROC.

where the lychee has been cultivated for about 200 years [2].

The variation of fruits within tree is mainly affected by environmental factors. Generally the fruits harvested from sun-exposed outer zone of canopy were better than from shaded inner parts in fruit quality and characters. Hwang (1966) resported that the fruits harvested from the top and south of the tree were better than from the inside in fruit weight, fruit color and aril weight in "Hak Ip" variety of lychee [2]. Jackson *et al* (1971) emphasize that the storage quality was also different within tree in apple, and suggested picking and storing fruits from the exposed and shaded parts separately. Significant difference in fruit quality and mineral composition in fruits were also reported in citrus such as Valencia orange [6,10], grapefruit [11], Matou Wentan [8] and grape [12]. Sampling technique was also developed to minimize the errors caused by different positions within tree [10].

Shrivelled seeds (or small seeds, chicken tongue seeds) are the seeds that fail to develop fully. It is one of the most preferable fruit characters of lychee [1,2]. The percentage of shrivelled seeds changed depending on the varieties, locations, trees, management ands year [2]. The "Groff" variety could reach 90% of shrivelled seeds in Hawaii [13]. "Yu Her Pao", "No Mai Tze" and "Kwai Mi" were reported with higher percentage of shrivelled seeds and excellent fruit quality in Taiwan [2]. Due to poor pollination, the yield of these varieties were lower and unstable as compare with "Hak Ip". Accordingly only limited amount of shrivelled-seed varieties were planted for commercial purpose. As to "Hak Ip" variety, though fair in quality and rarely with shrivelled seeds, it is prominent for its high and stable yield performance. In recent years, two newly found varieties named as "Sah Keng" and "Kang Wei" separately, which might also introduced from Southern China, appear promising for their high yielding and high percentage of shrivelled seeds [3]. Few reports were made on these two varieties, however. The purpose of this study were to 1) understand the extent of variation of fruit characters within tree and among trees and minimize the sampling errors of further studies, 2) compare the fruit characters between normal-seed variety "Hak Ip" and shrivelled-seed varieties "Sah Keng" and "Kang Wei", 3) compare the fruit characters between normal-seed fruits and shrivelled-seed fruits within shrivelled-seed varieties, 4) understand the relationship between seed size and other fruit characters and the possibility of predicting the shrivelled seeds by fruit characters.

MATERIALS AND METHODS

Two shrivelled-seed varieties "Sah Keng" and "Kang Wei" were harvested separately from Chuchi and Wufeng where they were found. The "Hak Ip" variety from the same orchard was also harvested to compare the fruit characters between varieties. Since "Hak Ip" is the most popular and prominent variety in Taiwan. The fruit from other two locations were harvested to understand the variation of fruit characters among locations. The varieties, locations and date of harvest were listed as follows :

Varieties	Locations	Date of harvest
Sah Keng	Chuchi, Chiayi	June 15, 1982
Kang Wei	Wufeng, Taichung	July 4, 1982*
Hak Ip	Chuchi, Chiayi	June 15, 1982
Hak Ip	Wufeng, Taichung	June 27, 1982
Hak Ip	Minhsiung, Chiayi	June 21, 1982
Hak Ip	Nantou, Nantou	June 30, 1982

*"Sah Keng" and "Hak Ip" almost matured at the same time, "Kang Wei" matured about one week later than "Hak Ip".

Five trees about ten-years old were selected randomly in each location. The crown of each tree was devided into six sections according to directions and positions on the tree, that is, east west, north, south, top and inner part. The fruits of 4 directions (east, west, south and north) were harvested from outer portions of canopy (in 0.5 meter from surface of canopy toward inside).

The following fruit characters were measured: length of fruit (FL), diameter of fruit (FD), weight of fruit (FW), shell color of fruit (FC), protuberances on the shell (FS), weight of shell (SW), Soluble solids (SS), flavor (FLV), length of seed (SL), diameter of seed (SD), percentage of shrivelled seed (RA) and ratio of aril weight in whole fruit (A/W). The shell color was rated from 1-10, the fruit full of red color was rated as 10 while that of light green was rated as 1. The protuberances on the shell was scored from 1-5. More smooth shell and with no apparent protuberance was rated higher, while prominent protuberances was rated lower. The color of aril was rated from 1-5. More transparent aril was scored higher, pale white was lower. The flavor of fruit was also scored from 1-5, more delicious and sweeter fruit was higher, off-flavor and acid fruit was rated as 1.

The data of fruit characters from each location was analyzed. After homogeneity test of variance, the "Hak Ip" variety from four locations were subjected to combined analysis. The variation within tree, among trees and among locations and the correlation coefficients between fruit characters were also computed.

RESULTS

The Variation of Fruit Characters within and among Trees

The variation of fruit characters within and among trees were presented in Table 1. In general most fruit characters were not significantly different within tree, while the

differences among trees were significant. The fruit length, fruit diameter, fruit weight, shell weight and aril weight showed this trend. The protuberances on the shell, aril color, percentage of shrivelled seeds and ratio of aril weight in fruit were not significantly different both within and among trees in most locations. Only "Hak Ip" variety from Minhsiung showed significant difference among trees on percentage of shrivelled seeds. Apparently genetic difference existed among trees in this orchard. The soluble solids and flavor were significantly different within and among trees in "Hak Ip" from Chuchi and in "Kang Wei" variety, while the difference were not significant in other locations. The soluble solids content of fruits harvested from outside of canopy were higher than from inside (Table 2). The variation of fruit diameter was irregular and different from that of soluble solids content.

Table 1. Test of significance of fruit characters within and among trees in three lychee varieties.

Varieties[1] & Locations	Source of Variation	df	Fruit Characters[2,3]													
			FL	FD	FW	FC	FS	SW	AW	AC	SS	FLV	SL	SD	RA	A/W
SK CC	Within Tree	5	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Among Trees	4	**	**	**	ns	ns	**	**	ns	ns	ns	*	*	ns	ns
KW WF	Within Tree	5	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns
	Among Trees	4	**	ns	ns	ns	*	ns	ns	ns	**	**	ns	*	ns	ns
HI CC	Within Tree	5	ns	*	ns	**	ns	ns	ns	ns	**	*	ns	ns	ns	ns
	Among Trees	4	**	**	**	**	ns	**	ns	ns	*	*	**	ns	ns	ns
HI WF	Within Tree	5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Among Trees	4	**	**	**	ns	ns	**	**	ns	ns	ns	ns	ns	ns	*
HI HH	Within Tree	5	ns	ns	*	ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns
	Among Trees	4	*	**	**	*	ns	**	**	**	nn	ns	**	**	**	ns
HI NT	Within Tree	5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Among Trees	4	**	*	**	**	**	**	**	**	ns	ns	ns	ns	ns	ns
HI Combined	Within Tree	5	ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Among Trees	4	**	**	**	*	ns	**	**	ns	ns	ns	ns	ns	**	ns
	Among Locations	3	**	**	**	**	**	**	**	**	**	**	**	**	**	**

1. Varieties : SK=Sah Keng, KW=Kang Wei, HI=Hak Ip.
Locations : CC=Chuchi, WF=Wufeng, MH=Minhsiung, NT=Nantou.
2. Description of fruit characters : see materials and methods.
3. ns : not significant, * : significant at 0.05 level, ** : significant at 0.01 level.

Table 2. The variation of soulble solids and fruit diameter of fruits from different positions on the trees in three lychee varieties.

Varieties & Locations	Hak Ip (Chuchi)	Hak Ip (Wufeng)	Sah Keng (Chuchi)	KangWei (Wufeng)
Soluble Solids				
East	17.1 ab	18.0	16.4	18.6 a
West	16.3 b	18.2	15.8	17.7 bc
South	16.5 b	17.5	16.0	18.0 abc
North	17.2 ab	18.3	16.4	17.7 bc
Top	17.9 a	17.8	15.9	18.4 ab
Inside	16.5 b	17.6 (ns)	15.9 (ns)	17.6 c
Fruit Diameter				
East	3.34 ab	3.40	3.44	3.33
West	3.37 a	3.41	3.41	3.34
South	3.34 ab	3.45	3.35	3.35
North	3.25 abc	3.40	3.34	3.33
Top	3.23 bc	3.43	3.20	3.36
Inside	3.20 c	3.43 (ns)	3.28 (ns)	3.42 (ns)

* Mean within column followed by the same letter are not significantly different at 5% level.

Estimates of variance components indicated that variation among trees contributed more to the total variability than within tree. In combined analysis of four location of "Hak Ip" showed variation among locations was much higher than among trees and within tree. The fruits from Wufeng gave the highest value on all fruit characters in four locations (Table 3).

Table 3. The variation of fruit characters of "Hak Ip" lychee at four locations.

Locations	Fruit Length	Fruit Diameter	Fruit Weight	Shell Weight	Aril Weight	Soluble Solids	Seed Length	Ratio of Aril in Whole Fruit
Wufeng	3.46 a	3.42 a	22.7 a	3.5 ab	16.7 a	17.9 a	1.97 b	0.73 a
Nantou	3.37 b	3.32 b	20.8 b	3.6 a	14.5 b	17.4 b	2.03 ab	0.69 b
Chuchi	3.41 ab	3.29 b	19.9 c	3.4 bc	13.9 bc	16.9 c	2.04 a	0.69 b
Minhsiung	3.38 b	3.20 c	19.2 c	3.2 c	13.5 c	17.0 c	1.90 c	0.70 b

* Mean within column followed by the same letter are not significantly different at 5% level.

Comparison between Normal-seed Variety "Hak Ip" and Shrivelled seed Varieties "Sah Keng" and "Kang Wei".

Comparison between "Sah Keng" and "Hak Ip" varieties were shown in Table 4. With the exception of fruit color and aril weight, other characters were significantly

different between varieties. The percentage of shrivelled seeds of "Sah Keng" reached 36% in comparison to 0% of "Hak Ip". The "Sak Keng" variety was also superior on fruit size, fruit weight, and aril weight. The protuberances on the shell of "Sah "Keng" was more prominent than that of "Hap Ip", while the aril color was not so transparent as the 'Hak Ip'. The ratio of aril weight is not significantly different between these two varieties. Though the soluble solids and flavor of "Sah Keng" was lower than the "Hak Ip", however it was not detected easily by tasting. The mean of seed size of Sah Keng was smaller than that of Hak Ip.

The fruit size, fruit weight and aril weight of "Kang Wei" were smaller than "Hak Ip" variety (Table 4). The shrivelled seeds of "Kang Wei" was 26%, higher than "Hak Ip". The rank of protuberances on shell of fruit was significantly different between varieties, however it could not be distinguished on the basis of fruit appearance. The soluble solids content, flavor and aril weight ratio were not significantly different between "Kang Wei" and "Hak Ip" varieties.

Table 4. Comparison of fruit characters between normal-seed variety "Hak Ip" and shrivelled-seed varieties "Kang Wei" and "Sah Keng" in lychee.

Varieties	Fruit					Characters*							
	FL	FD	FW	FS	SW	AW	AC	SS	FLV	SL	SD	A/W	RA
Sah Keng	3.60	3.36	21.2	3.5	4.2	14.9	3.7	16.1	3.4	1.6	1.1	0.70	36
Hap Ip	3.41	3.29	19.9	3.9	3.4	13.9	4.1	16.9	3.6	2.0	1.3	0.69	0
LSD 5%	0.05	0.06	1.0	0.11	0.15	0.8	0.1	0.4	0.12	0.1	0.1	0.01	8
1%	0.07	0.08	1.3	0.15	0.20	1.0	0.1	0.5	0.16	0.1	0.1	0.01	11
Kang Wei	3.25	3.36	21.3	4.5	3.6	15.9	4.1	18.0	4.2	1.7	1.1	0.75	26
Hak Ip	3.46	3.42	22.7	4.4	3.5	16.7	4.4	17.9	4.3	2.0	1.3	0.74	0
LSD 5%	0.05	0.04	0.7	0.07	0.16	0.5	0.1	0.3	0.11	0.1	0.1	0.01	6
1%	0.06	0.05	0.9	0.09	0.21	0.7	0.1	0.4	0.15	0.1	0.1	0.01	8

*Description of fruit characters : see materials and methods.

Comparison between Normal-seed and Shrivelled-seed Fruits within Shrivelled-seed Varieties "Sah Keng" and "Kang Wei"

After fruit characters were measured, the data of shrivelled seed varieties were devided into two sets according to the seed size. The seed length and diameter above 1.5 and 1.0cm were assigned as normal seed, the seed length and diameter smaller than 1.5 and 1.0cm were shrivelled seeds. The fruit characters between normal- and shrivelled-seed fruits wers compared and the correlation coefficients were estimated in two varieties separately. The results were shown in Table 5 and Table 6. The fruit length, fruit diameters, fruit weight and shell weight of shrivelled-seed fruits were smaller than normal-seed fruits in both varieties. The ratio of aril weight in shrivelled-seed fruit was higher than normal-seed fruit. Evidently, it was affected by seed size. The soluble solids and flavor were not significantly different between shrivelled- and normal-seed fruits. Both shrivelled seed varieties showed the same results in comparing the fruit characters between normal- and shrivelled-seed fruits.

Table 5. Comparison of fruit characters between fruit with normal and shrivelled seed within variety in lychee.

Variety	Seed Size	Fruit				Characters*			
		FL	FD	FW	SW	AW	SS	FLV	A/W
Sah Keng	Normal	3.67	3.46	22.8	4.5	15.4	16.1	3.5	0.63
	Shrivelled	3.50	3.17	18.2	3.6	13.6	15.7	3.3	0.75
	LSD 5%	0.12	0.12	1.0	0.1	1.2	0.5	0.3	0.03
	1%	0.21	0.20	1.7	0.2	1.9	0.8	0.4	0.05
Kang Wei	Normal	3.23	3.41	22.1	3.7	16.2	18.0	4.2	0.73
	Shrivelled	3.21	3.28	19.7	3.3	15.7	18.1	4.2	0.80
	LSD 5%	0.02	0.07	1.3	0.3	0.8	0.2	0.1	0.02
	1%	0.04	0.11	2.2	0.5	1.4	0.3	0.2	0.03

*Description of fruit charactrse : see materials and methods.

Since seed size was composed of seed length and seed diameter, these two characters were used in calculating the correlation coefficients with other fruit characters. The seed length and seed diameter were positively correlated with fruit diameter, fruit weight and shell weight in both shrivelled seed varieties. The correlation between seed size and aril weight, soluble solids content and flavor were not significant (Table 6). The ratio of aril weight in fruit was negatively correlated with seed size. The correlation coefficients between seed size and other fruit characters were low or nonsignificant in normal-seed variety "Hak Ip".

Table 6. The correlation coefficients between seed size and fruit characters in three lychee varieties.

Fruit Characters	Sah Keng Variety		Kang Wei Variety		Hak Ip Variety	
	Seed Length	Seed Diameter	Seed Length	Seed Diameter	Seed Length	Seed Diameter
Fruit Length	0.42 ns	0.47 ns	0.46 ns	0.43 ns	0.18 ns	0.05 ns
Fruit Diameter	0.68 *	0.70 *	0.90 **	0.94 **	0.16 ns	0.23 *
Fruit Weight	0.77 **	0.79 **	0.87 **	0.85 **	0.17 ns	0.27 **
Shell Weight	0.73 *	0.77 **	0.83 **	0.82 **	0.12 ns	0.11 ns
Aril Weight	0.52 ns	0.53 ns	0.44 ns	0.42 ns	0.02 ns	0.13 ns
Soluble Solids	0.40 ns	0.47 ns	0.10 ns	0.04 ns	− 0.04 ns	0.19 *
Flavor Score	0.60 ns	0.59 ns	0.15 ns	0.13 ns	− 0.23 *	0.06 ns
Ratio of Aril Wt. in Fruit	− 0.89 **	− 0.92 **	− 0.96 **	− 0.96 **	− 0.36 **	− 0.28 **

ns : not significant.
* : significant at 5% level.
** : significant at 1% level.

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The variation within tree was not so large as among trees in most fruit characters. Estimates of variance components indicated that variation among trees contributed more to the total variability than within tree. Because of larger variability among trees, sampling more trees and less samples within a tree will gain an estimate of desired accuracy. The soluble solids contents is postulated as the synonym of quality in lychee. Higher value of soluble solids was obtained when the fruits harvested from outer portion of canopy where most of lychee fruits were produced. Avoiding to pick the fruits from inner parts will reduce the errors of sampling. Li *et al* studied the variation of fruits in Matou Wentan and tankan also found that the variance components among trees and among orchards were larger than within tree[7,8]. The variance component within tree were not over 10% of total variability in all fruit characters measured in Matou Wentan[8]. Through the calculation of variance components within tree and among tree, the repeatability of Matou wentan and tankan were estimated. It provides some genetic information of fruit characters when the heritability could not be obtained[7,8]. Since there was no report on the genetic behaviors of fruit characters of lychee, study of repeatability based on variance components within and among trees would be valuable.

The variation within tree could be classified into two group: First, the soluble solids content and fruit color changed with the different positions on the tree. The fruits from outer portion of canopy tend to have a higher value than that from inside. Secondly, the fruit size, fruit weight, aril weight and seed size were less affected by different positions. This result was different from Huang's reports. Huang found that the fruits from south direction were larger and heavier in size and weight than those from the other directions, but the soluble solids from south and top were lower than those from inside[2]. The sampling method may explain the different results. In this experiment, the fruits of four directions (east, west, south and north) were harvested from outer postion of canopy, but not from inner parts. Oranges from southern top canopy sectors also tend to have higher concentration of soluble solids and juice content than from other sectors[10]. Jackson found the apple fruits from the outer zones of the tree were larger, better colored and shrivelled and appeared to be more matured in terms of ground color than fruits from the inner zones. After storage the fruits from the outer zone developed significantly less core flush, higher incidence of bitter pit and rotting than fruits from the inner zones[5]. The differences between positions within tree were also reported in grapefruit[11], Matou Wentan[8] and grape[12].

The "Hak Ip" is a variety with normal seeds. The difference of seed size among trees were not significant. Huang reported only 1.79% of shrivelled seeds was obtained in natural condition[2]. However, 100% of shrivelled seeds could be gained in bagging and without artificial pollination[4]. In this study, the percentage of shrivelled seeds in 3 locations were zero, while from Minhsiung, two plants with 25% and 50% of shrivelled seeds repectively were recorded in natural condition. It indicated, apparently, that genetic differences exist among trees in this orchard.The percentage of shrivelled seeds were different

by varieties, years, management and locations [2]. This study showed that the differences within and among trees were not significant in the same location in shrivelled varieties "Sah Keng" and "Kang Wei". It is unknown however that to what extent will be affected by different locations and years.

Comparison of "Hak Ip" variety from four locations showed the fruits from Wufeng ranked the highest value in all characters measured. It may be due to the effect of both genetic and environmental factors. Further study should be carried out to completely understand and explain which factor contributed more to the differences of fruit characters among locations.

The "Sah Keng" and "Kang Wei" varieties were apt to produce higher percentage of shrivelled seeds. Huang reported that the shrivelled seeds of "Yu Her Pao", "No Mai Tze" and "Kwai Mi" were 31.43%, 26% and 35.85%, respectively [2]. He also explained due to the rearing of bees, the shrivelled seeds of "Sah Keng" were reduced from 57.56% to 36.6% [3], the result is close coincide to this experiment where the shrivelled seeds of "Sah Keng" and "Kang Wei" were 36% and 26%, respectively. Rearing the bees in the orchards may explain the lower value of shrivelled seeds, but they were still close to the "Yu Her Pao", "No Mai Tze" and "Kwai Mi" [2]. The quality in terms of soluble solids of these two varieties were similar or approximate to "Hak Ip" variety. The yield of two shrivelled seed varieties were approximate to "Hak Ip" [3], but were higher and more stable than other shrivelled seed varieties such as "Yu Her Pao", "No Mai Tze" and "Kwai Mi". The maturity time of "Sah Keng" is the same as "Hak Ip", while the "Kang Wei" is about one week later than "Hak Ip". The different maturity time of two shrivelled seed varieties will extend the lychee supply in Taiwan where the lychee market was limited in two months for its short postharvest life [9]. The "Sah Keng" and "Kang Wei" would appear promising for higher percentage of shrivelled seeds and more stable yielding than other shrivelled seed varieties.

The consumer prefer shrivelled-seed fruits. Huang reported that the fruits with shrivelled seeds are better in quality than normal-seed fruits. To compare whether there are any difference between normal- and shrivelled-seed fruits, the fruits were devided into two sets depending on the seed size as described above. The shrivelled-seed fruits were smaller and lighter in fruit size and weight, but no difference in soluble solids content. It is evident that the quality between normal- and shrivelled-seed fruits were similar within variety. The shrivelled-seed fruits were superior for their smaller seed size, higher aril ratio and separate the seed and aril easily, but not for better quality. Improvement of quality could only be effectively obtained by breeding methods.

It is difficult to predict the shrivelled seeds from outer characters of fruits. The calculation of correlation coefficients between seed size and other fruit characters may provide valuable informations for predicting the shrivelled seed from outer characters of fruits. The seed size were highly correlated to fruit diameter, fruit weight and shell weight in two shrivelled-seed varieties. The fruit diameter and fruit weight could be measured without breaking the fruits. They would be useful index to predict the shrivelled

seed. This results confirm Huang's report and farmers' experience[2]. However, the correlation coefficients of "Hak Ip"variety were low and not significant showed the fruit characters were less affected by seed size in normal-seed variety.

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荔枝大核與小核種果實性狀變異之研究[1]

顏 昌 瑞[2]

摘 要

研究荔枝小核種沙坑及港尾晚生與大核種黑葉果實性狀品種間、株間與株內之變異，由變方分析結果顯示果實性狀株間變異大於株內變異；最廣泛栽培黑葉之四個地區綜合分析結果顯示地區間果實性狀變異大於株間及株內。果長、果徑、果重、果殼重及果肉重等性狀株間之差異為顯著，而株內差異不顯著；在多數地區之果棘、果肉色、小核率及果肉率於株間及株內之差異均不顯著；而可溶性固形物，風味及種子大小之差異因地區及品種而有異。

沙坑、港尾晚生及黑葉等品種之小核率分別為36%、26%及 0 %，二小核種之可溶性固形物與黑葉種相近，其他性狀之差別亦於本文中分別比較。

比較小核種沙坑及港尾晚生品種內大核果及小核果之差異，顯示大核果之果實大小及果重略大於小核果；但其可溶性固形物含量差異不顯著；小核果較大核果之優點為種子小，高果肉率及易於剝除果肉。二小核種之果徑、果重及果殼重與種子大小之相關均高且顯著，而大核種果實性狀和種子大小之相關係數均低且不顯著。

1.臺灣省農業試驗所 研究報告第1080號。
2.嘉義分所園藝系助理研究員。臺灣省 嘉義市。

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Seasonal Variation Affecting Sex Expression of Coba (*Zizania latifolia* Turcz.)[1]

Tsung-Dao Liou[2]

Abstract : Coba (*Zizania latifolia* Turcz.) cv. Green Shell flowers continuously from early May to mid-November in southern Taiwan. It is monoecious, which male and female flowers occur on the same inflorescence. Each inflorescence consists of many spikelets and forms a large panicle. Most of male flowers distributed at the lower portion of spikelets in the inflorescence, while the female flowers distributed oppositively. The length of inflorescence, inflorescence node, and lateral inflorescence ; no. of lateral inflorescences, total flowers, deformed flowers, male flowers vary with the flowering month. The length of flower inflorescence, inflorescence node and lateral inflorescence do not vary from May to September, but decrease after October. The no. of lateral inflorecence, total flowers, deformed flowers, male flowers and female flowers increase from May, reach a maximum in August or September, and then decrease. The ratio of male/female flowers is highest (at 4 : 1) in May and then gradually decreases to 2 : 1 in July and August, to 1 : 1 in October, and then sharply decreases in November with veryfew (if any) male flowers.

Coba is a perennially ratooned aquatic vegetable , tolerant to heat and flooding. It is popularly cultivated in tropical and sub-tropical swamp areas and paddies (19,49,56). Farmers continue to plant young coba seedlings from late November to early March of next year (27,30). Young seedlings did not elongate but malformed swollen galls when infected by *Ustilago esculenta* P. Henn. on the base parts of 4 or 5 node of coba stem. This edible gall is called "Kah- Peh-sung" (local name) or "water shoot" (10,17,18,32,33,50,57,58,59) and is a very important summer vegetable during monsoons of Taiwan (26,31,51). On the contrary, the stem has no gall formation and continue to elongate and flower if plant was not infected by fungus (29,57). Liou (1977) showed the cultivar Green Shell of coba flower continuously from early June to late October in southern Taiwan. The plant is monoecious, and the inflorescence is one large typed panicle or compound raceme and

1. Contribution No. 1081 from the Taiwan Agricultural Research Institute.

2. Assistant Horticulturist, Fengshan Tropical Horticultural Experiment Station, TARI, Fengshan City , Kaohsiung Hsien , Taiwan 830, ROC.

consists of many lateral inflorescence, secondary lateral inflorescence and spikelets. Most of female flowers are located in upper parts of inflorescence. Whereas, most of male flowers are concentrated in lower parts. There is almost equal number of male and female flowers (the ratio of male flowers to female flowers about 1 : 1) in the middle part of inflorescence when flowers in July [29]. The variation of the flower morphology, number of male and female flowers and changes of sex expression on the other months still unclear. This present continued on previous research [29] for studing the seasonal variation in sex expression of coba under natural conditions. This information may offer to the people who are interested to the coba researches.

Material and Methods

The most popular cultivars of coba, cv. Green Shell was used. The young coba seedlings were planted in the experimental farm of Fengshan Tropical Horticultural Experiment Station, TARI, on March 15, 1978 and March 11, 1979, respectively. One hundred of young coba seedlings were planted in each experiment. The growing seedlings were managed in accordance with the general coba culture methods. Six of normal flowered inflorescence were sampled to investigate plant height of flowering tillers, length of flower inflorescence, length of lateral inflorescence, no. of lateral inflorescence, length of inflorescence node, no. of inflorescence node, no. of flowers per inflorescence, no. of deformed flowers per inflorescence, no. of male flowers per inflorescence, no. of female flowers per inflorescence and ratio of male to female flowers at one week interval for two weeks in the months of May and November, and for four two weeks in the other months. There were 144 inflorescences of each year were investigated.

Results

I. Effects of seasonal variation on the inflorescence morphology of coba

1. Effects of seasonal variation on the plant height of flowering tillers of coba.

Young coba tillers continued to grow up from the crown of young coba seedlings. When the base nodes of those young tillers were infected by *Ustilago esculenta* P. Henn, the stem of those young tillers malformed and swolled and formed an edible gall. On the contrary, if the stem node of the tillers were not infected to the fungus, the stem continued to elongate and flower [28,29,32,33,50,57,58,59]. The tillering pattern of coba were same as sugar cane. All the tillers on the same crown (plant) do not come up at the same time, but grow up from the crown continuously. This is the reason why the plant height of flowering tillers appeared a great variation at the flowering time of the inflorescences. Figure 1 shows the plant height of flowering tillers appeared significant difference under different flowering seasons. The plant height of flowering tillers in May was 160–180 cm, then gradually increased and revealed the highest of 190–210 cm in July and August, and then gradually decreased to the reach lowest of 140 cm in November.

2. Effects of seasonal variation on the length of inflorescence of coba

Figure 2 shows the length of coba inflorescence differed with appeared the seasonal

variation. Although, the length of inflorescence did not differ in May to September, but it appears to decrease after September. The length of inflorescence flowered in May was about 70 cm, then reached to the longest of 75-80 cm in July and August, then decreased the shortest of 25-30 cm in November.

3. Effect of seasonal variation to the length of node and lateral inflorescence of coba

Figure 3 shows the length of node of inflorescence did not vary when plants flowered from May to September, but decreased after October. The length of node of inflorescence was about 4 cm in May and shortened to about 1.5 cm in November. The variation of lateral inflorescence was the same tendency of the node length. The length of lateral inflorescence also did not vary from May to September, but decreased after October. The length was about 11-13 cm when flowered from May to September then decreased sharply to only about 7 cm in November.

4. Effect of seasonal variation to the no. of node and lateral inflorescence of coba

Figure 4 shows the no. of node of inflorescence (18-20) reached to the maximum in July and August, but did not vary with other months. The no. of lateral inflorescence was about 40 in May, then reached to the maximum of about 55-60 in July and August, and 40 in November.

II. Effect of seasonal variation to the distribution of male and female flowers on the inflorescence of coba

The distribution of male and female flowers on the inflorescence varied with different months. Figure 5 and 6 show the distribution of male and female flowers on inflorescence which appeared to have a regular tendency from May to September, except October and November. Most of male flowers concentrated in lower parts of inflorescence and female in upper parts. The ratio of male/female flowers decreased when the inflorescence node increased. There was almost equal number of male and female flowers in the middle part of inflorescence. The male and female flowers located on the node position of the inflorescence also differed with different months. The location of male and female flowers on the inflorescence and the ratio of male to female flowers on the node sequence of inflorescence had a regularly tendency from May to September. The ratio of male/female flowers on the node sequence of inflorescence derceased as the node sequence increased from May to September, but the ratio decreased after October. The ratio of male/female flowers about 1 : 1 on the node sequence of 4-5 node when it flowered in October and with only very few (if any) male flowers when the plants flowered in November.

III. Effect of seasonal variation on the no. of flowers and sex expression of coba

Coba is monoecious aquatic plant. The male, female and deformed flowers are distributed on the same inflorescence. The total no. of flowers per panicle varied with different months. Figure 7 shows that 1,500-1,600 flowers per panicle (inflorescence) were formed in May and then reached to the maximum of 2,400-2,600 flowers per panicle during July, August and September, but decreased in October and November to about 1,000 and 250-300 flowers per panicle respectively.

The no. of deformed flowers also varied with different months. The no. of deformed

flowers per panicle was about 110–160 flowers in May, and reached to the maximum of 120–180 during June, July and August, but there was no great difference during June, July and August as compared with May and its decreased after September and reached to the minimum of 60 in November.

The no. of male, female flowers and the ratio of male to female flowers also varied with different months. The no. of male flowers per panicle were 1,000–1,200 flowers in May, and reached to the maximum of 1,400–1,600 in July and August. The no. of female flowers per panicle was about 300 flowers in May and reached to the maximum of 700–900 in July, August and September. The ratio of male to female flowers shows the highest at 4 : 1 in May and then decreased to 2 : 1 in July and August. The no. of male flowers decreased after September and reached 400–500 flowers per panicle in October. On the same time, the female flowers also decreased to about 500 flowers per panicle in October with ratio of about 1 : 1, and only very few (if any) male flowers on the panicle in November.

The percentage of deformed flowers, male flowers and female flowers on panicles also shows varied during different months. Figure 8 shows only 10% of deformed flowers without much variation during flowering months except 20% in November. There is 70–75% of male flowers on the panicle which is the highest proportion of male flowers in May and then decreased. In October, there is 40% male flowers and in November only very few male flowers produced. There are very low percentage of female flowers in the early stage then gradually increased with time of flowering. Only 20% of female flowers on the panicle when flowered in May and then increased to 40% in September and reached to the maximum of 80% in November.

Discussion

The change of nodal sequence, sex expression and the ratio of staminate to pistillate flowers may be modified by hereditary factors, environmental factors or interaction of hereditary factors and environmental factors[13]. Currence (1932) has found that during the life of a cucumber plant there is a gradual change from staminate to pistillate condition. This change is related to the nodal sequence ; the lower nodes being predominantly staminate, and the upper nodes predominantly pistillate. Shifriss and Galun (1956) indicated that the lower the node number of the first pistillate flower, the higher the female tendency in the monoecious varieties of cucumber[48]. In this investigation we found that the distribution and nodal sequence of male and female flowers on the inflorescence of coba changes with time (Figure 5 and 6). The changes of nodal sequence of male and female flowers on the inflorescence and sex expression of coba were similar to the cucumber[7,48]. The changes of sex tendency may be affected by length of day, temperature, light intensity, and light quality or other environmental factors. However, what are the major factors which affect the variation of male and female flowers on the nodal sequence and sex expression in the inflorescence of coba need further studies.

Rosa (1928) indicated that the ratio of staminate to pistillate flowers of cucumber

varies greatly with different environmental conditions [42]. Edmond (1930) also indicated that sex expression of cucumber varies greatly due to seasonal variation and the ratio of opened staminate flowers to pistillate varied from 51 : 1 to 21 : 1 [9]. In this experiment, we found that the ratio of staminate to pistillate flowers of coba also varies greatly due to seasonal variation and the ratio of opened staminate flowers to pistillate varied from about 4 : 1 in May to about 1 : 1 in October and very few male flowers produced in November (Figure 7). On the changes of sex expression and sex ratio, Tiedjens (1928) indicated that nitrogen level may modify the sex expression and sex ratio of flowered cucumber plants. He indicated that high levels of nitrogen appear to promote male sex expression, whereas low levels favor female expression [54]. This fact has also been demonstrated in hemp and spinach [46,52,53]. However, how about of the nitorgen effect of sex expression and sex ratio of coba still unclear and need further studies.

Temperature and day length also influence on the sex expression of flowering plants. Tiedjens (1928) indicated that the reduction of light materially increases the number of pistillate flowers and decreases staminate flowers of the cucumber [54]. Hall (1949) was unable to alter flower ratio in the gherkin with different photoperiod ; [14] however, Nitsch et al (1952) later showed that short days promoted pistillate flower development in gherkin and squash while long days favored male expression [38]. Short day treatment has also been shown to cause a shift toward female sex expression in hemp, Japanese hop (*Humulus japonicus*, Sieb & Zucc.), maize, regweed (*Ambrosia elatior* L.) and cocklebur [18,36,44,45,57]. These are short day species with the exception of maize in which flowering is accelerated by short day treatment [41]. Conversely, in spinach, a long day plant, female sex expression is promoted by long days [52]. Heslop-Harrison (1957) has suggested that short days, low temperature, and high nitrogen levels may promote female sex expression of the hemp by increasing auxin concentration [16]. Brantley and Warren (1960) also indicated that medium and high nitrogen levels, and long days increased the number of staminate and perfect flowers as well as the proportion of perfect flowers in the muskmelon [4]. Atsmon and Galun (1962) indicated that the first nodal sequence of cucumber pistillate flowers decreased under high nitrogen levels and long day conditions [2]. It is clearly proved that the sex expression and ratio of staminate to pistillate flowers of plants are greatly influenced by temperature and day length. In this experiment, we also found that the number of male, female flowers and the ratio of staminate to pistillate flowers in the inflorescence of coba varies greatly during different flowering months have been mentioned (Figure 7). The clear variation of sex expression and sex ratio of coba in this experiment may be influenced by the changes of temperature and day length during the growth of coba. Figure 9 shows that normal temperature changes on the island are rising after April and reaches to maximum in June, July and August and decreases after September. Temperature in November is almost the same as March. Tendency of the changes of day length is almost the same as temperature. The month of May, June, July and August is considered to be a long day condition on the island and the day length shortened after September. The variation of male, female flowers number and ratio of stami-

nate to pistillate flowers of coba has the same tendency as changes of temperature and day length under different months. The results of this experiment and previous researches strongly indicated that the changes of sex expression and sex ratio of coba were deeply influenced by the variation of temperature and day length. But what is the critical point of these environmental factors need further studies.

Auxins or chemicals may also influenced sex expression of plants. Promotive effects of auxin on flowering have been reported in both long and short day species [8,24,25,35]. In contrast, inhibitions have been observed in may cases [22,24]. Laibach and Kribben (1950) proved a direct effect of auxin on sex expression in cucumber. Treatment with naphthaleneacetic acid increased the proportion as well as the total number of pistillate flowers [21]. Nitsch et al (1952) lowered the node at which the first pistillate flower of *Cucurbita pepo* L. appeared from the 20th to the 9th node with auxin applications [38]. Heslop-Harrison (1956) obtained similar results in hemp as pistillate flowers were formed on genetically male plants in sites normally occupied by staminate flowers [15]. Recently, Rudich, et al (1970), Lee and Janick (1978) indicated that the staminate flower formation of monoecious and andromonoecious lines of cucumber was decreased when treated with ethephon [23,43]. Byers et al (1972) reported on the use of 5-methyl-7-chloro-5-ethoxycarbonylmethoxy-2, 1, 3 benzothidiazole(MCEB)to maintain gynoecious muskmelon [6]. Anais (1971), Frankel and Galun (1977), Kubicki (1969) and Peterson (1963) have been tried without success in inducing perfect flowers on gynoecious lines cucumber by use of gibberellin A4/A7 [1,11,20,40]. Anais (1971) indicated that gynoecious lines of cucumber could be maintained by grafting onto various cucurbit stocks [1]. It has been found that large numbers of staminate flowers on gynecious genotypes cucumber was induced when treated with both silver nitrate and aminoethoxy-vinylglycine [3,5,12,37,39,55]. Auxins and chemicals were widely used to induce the formation of male flowers, female flowers and perfect flowers and to change the sex expression of cucumber and melon, however how about the effect of these chemicals to influence the flowering of coba is still needed for further studies.

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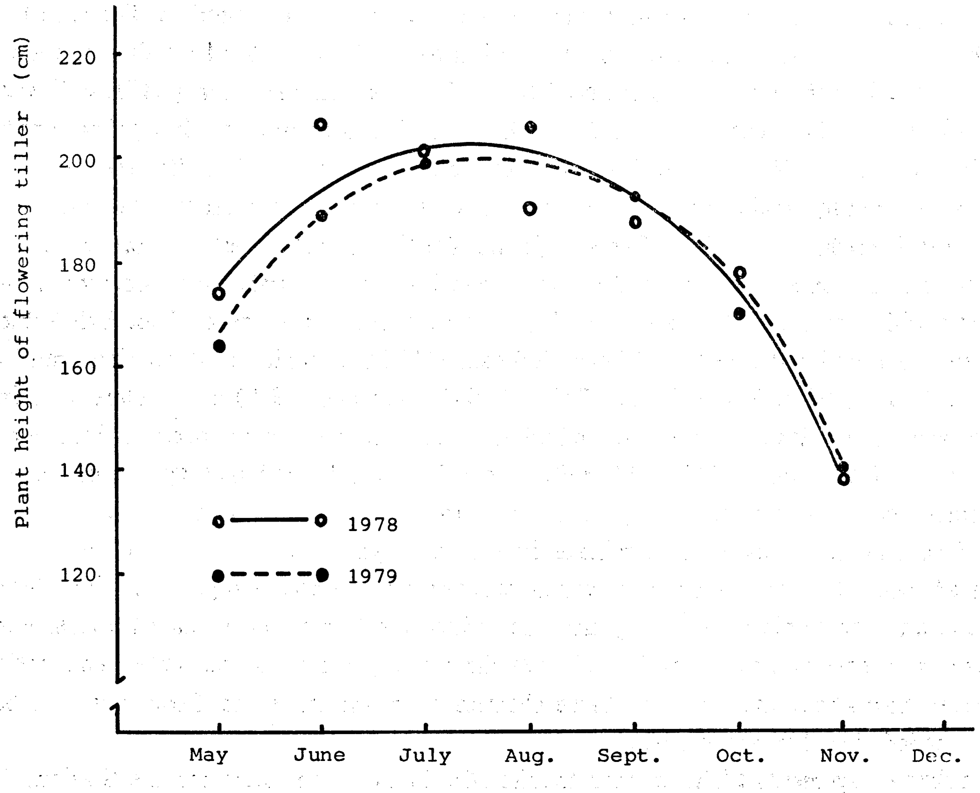


Fig. 1. Monthly variation in plant height of flowering tillers of coba (*Zizania latifolia* Turcz.) in 1978 and 1979.

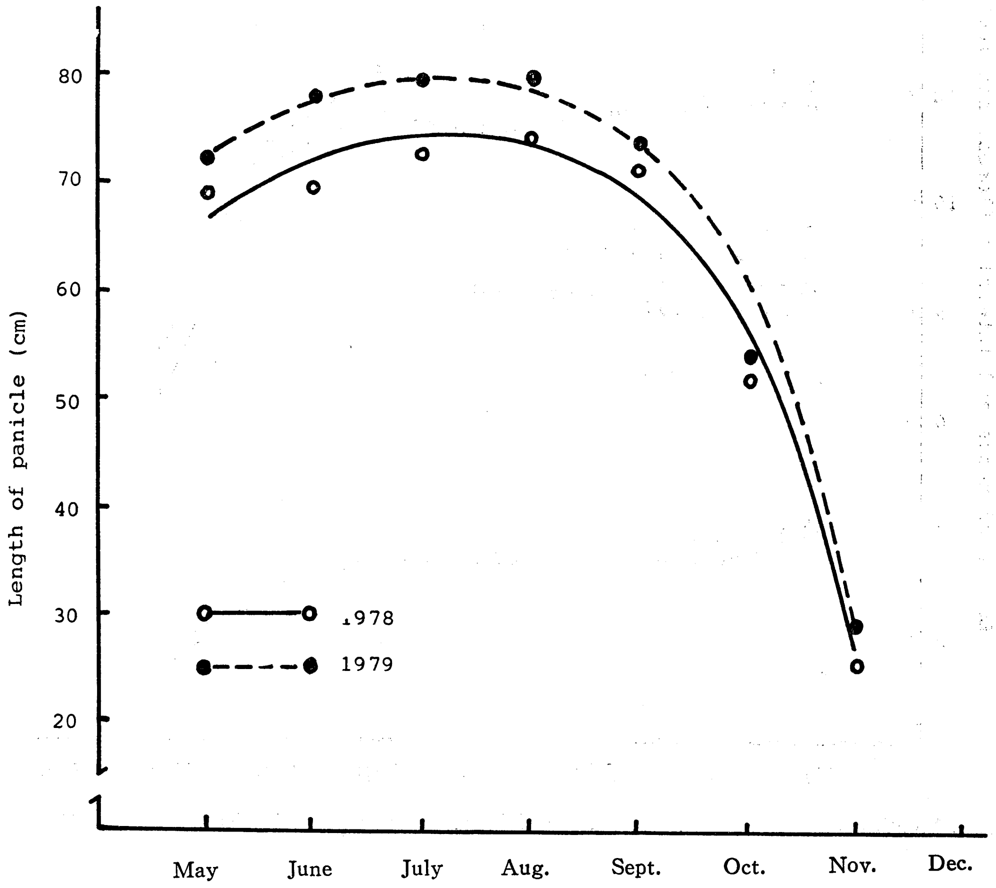


Fig. 2. Monthly variation in length of panicle of coba in 1978 and 1979.

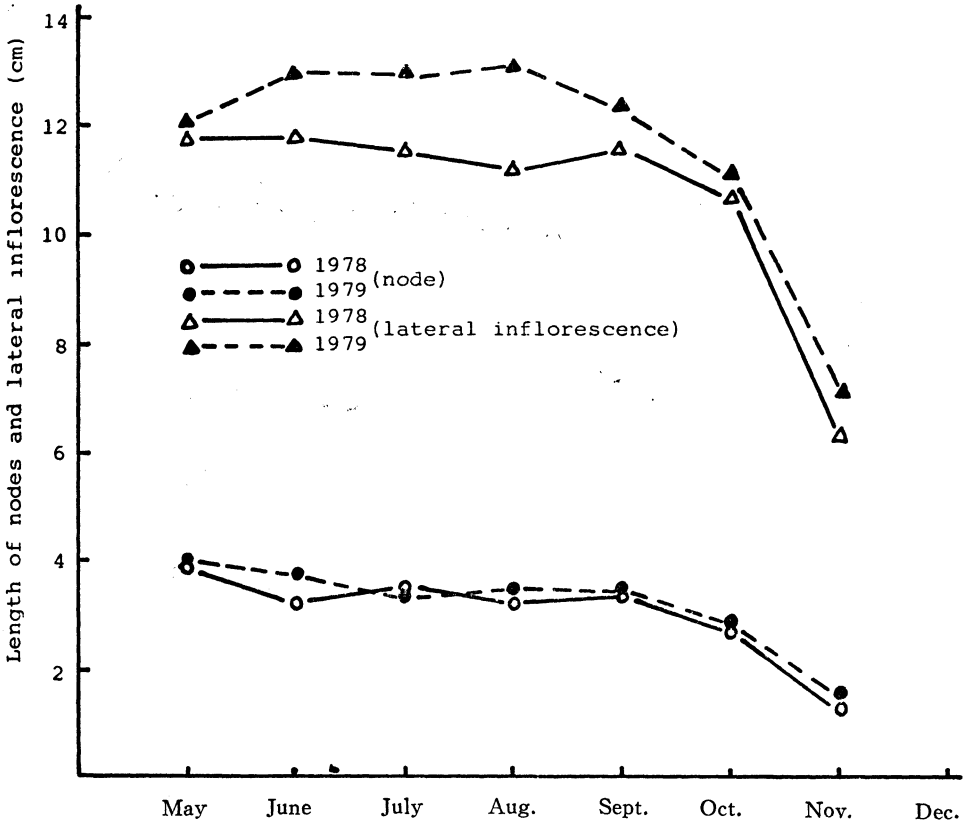


Fig. 3. Monthly variation in length of node and lateral inflorescence of coba in 1978 and 1979.

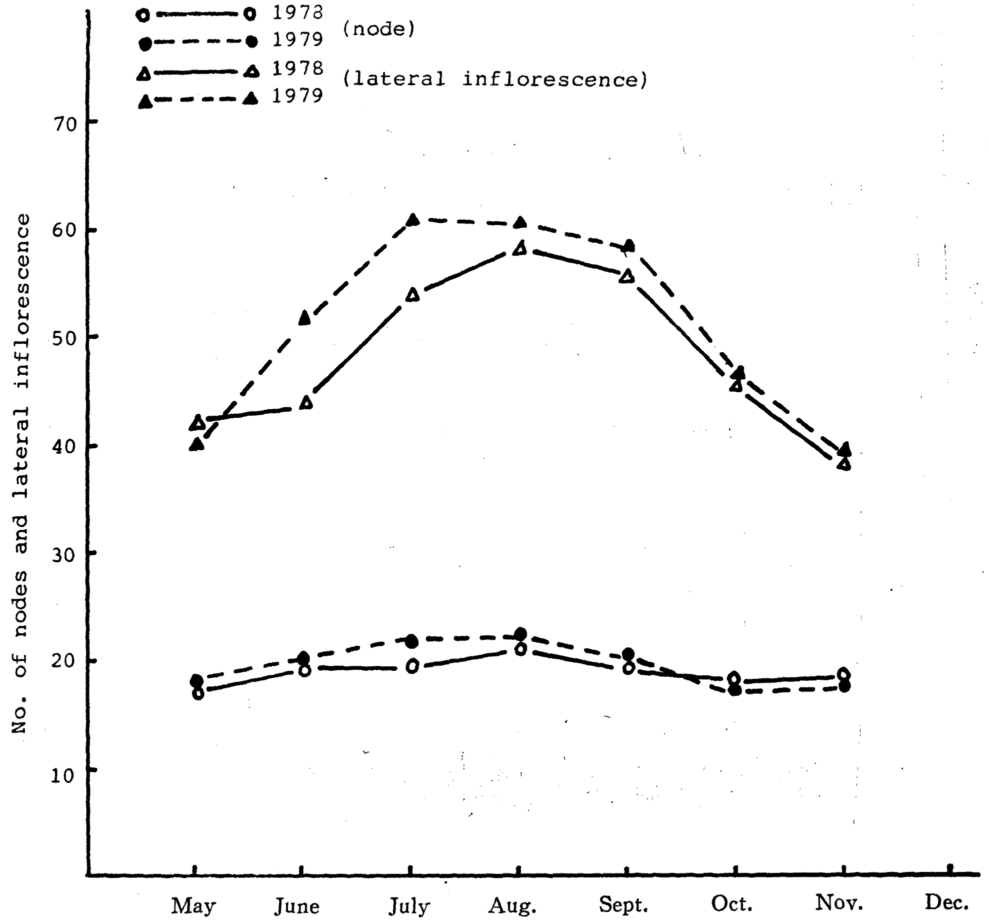
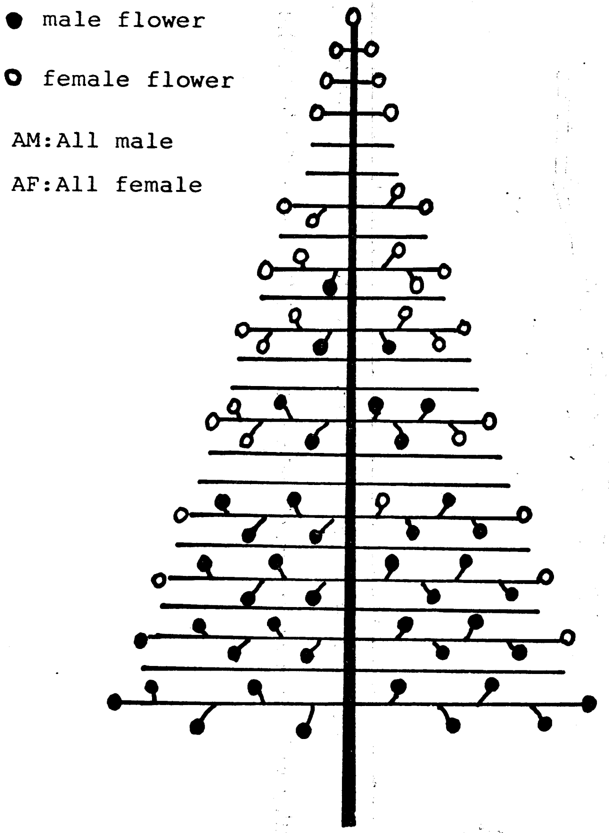


Fig. 4. Monthly variation in average no. of nodes and lateral inflorescence of coba in 1978 and 1979.



Sex ratio male/female = X*/1

May	June	July	Aug.	Sept.	Oct.	Nov.
			AF			
			AF			
	AF	AF	AF	AF		
	AF	AF	AF	AF		AF
	AF	AF	AF	AF	AF	AF
AF	AF	AF	0.1	AF	AF	AF
AF	AF	AF	0.3	AF	AF	AF
AF	AF	0.1	0.3	0.1	AF	AF
AF	0.1	0.2	0.4	0.2	AF	AF
0.2*	0.3	0.2	0.4	0.2	0.1	AF
0.4	0.5	0.7	0.6	0.4	0.1	AF
0.9	0.7	1.0	0.9	0.6	0.2	AF
0.7	1.0	1.1	1.1	1.0	0.3	AF
1.1	1.2	1.2	1.2	1.1	0.3	AF
1.7	1.6	1.4	1.4	1.0	0.5	AF
2.4	2.2	1.9	1.8	1.3	0.7	AF
3.2	2.9	2.0	1.8	1.5	0.8	AF
4.5	4.1	2.1	2.8	1.9	1.0	AF
5.6	4.8	2.2	3.4	2.3	1.0	AF
8.7	7.5	3.2	5.1	5.2	1.7	AF
20.1	20.8	5.3	6.1	7.4	2.0	AF
61.0	AM	51.0	58.1	AM	1.5	AF

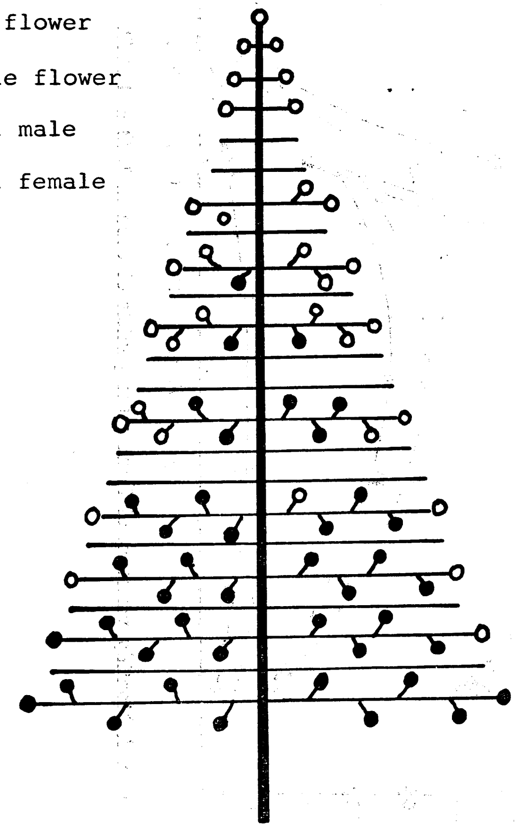
Fig. 5. Monthly variation of male and female flowers distribution pattern and sex ratio in the inflorescence of coba in 1978.

● male flower

o female flower

AM: All male

AF: All female



Sex ratio male/female = X* / 1

May	June	July	Aug.	Sept.	Oct.	Nov.
		AF	AF			
		AF	AF			
	AF	AF	AF	AF		
	AF	AF	AF	AF		AF
	AF	AF	AF	AF	AF	AF
AF	AF	0.3	0.1	AF	AF	AF
AF	AF	0.4	0.2	AF	AF	AF
AF	AF	0.4	0.4	0.1	AF	AF
AF	AF	0.6	0.5	0.1	AF	AF
0.1*	0.1	0.8	0.8	0.3	0.1	AF
0.3	0.4	0.8	0.8	0.4	0.2	AF
0.9	0.7	1.0	1.0	0.6	0.3	AF
0.7	0.6	1.2	1.2	0.7	0.3	AF
0.9	0.8	1.3	1.2	1.0	0.3	AF
1.3	0.8	1.6	1.5	1.0	0.5	AF
2.1	1.3	1.8	1.4	1.1	0.8	AF
2.5	1.6	1.9	1.5	1.1	0.9	AF
3.9	2.7	2.0	2.1	1.6	1.0	AF
5.0	3.6	2.3	3.2	2.1	0.9	AF
7.4	6.3	3.6	5.1	3.1	1.1	AF
13.1	10.1	5.7	4.8	3.4	1 5	AF
AM	AM	38 0	37.0	AM	1.2	0.5

Fig. 6. Monthly variation of male and female flowers distribution pattern and sex ratio in the inflorescence of coba in 1979.

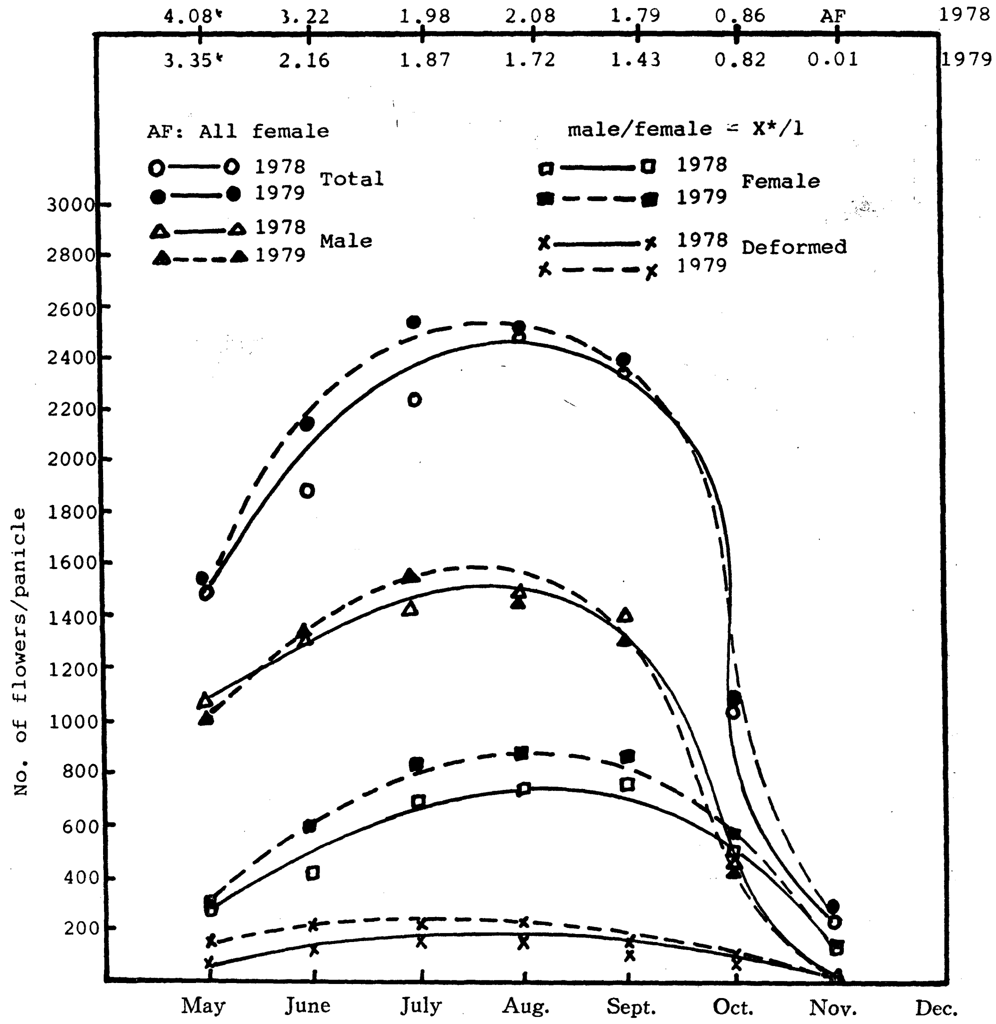


Fig. 7. Monthly variation of flowers per panicle of coba in 1978 and 1979.

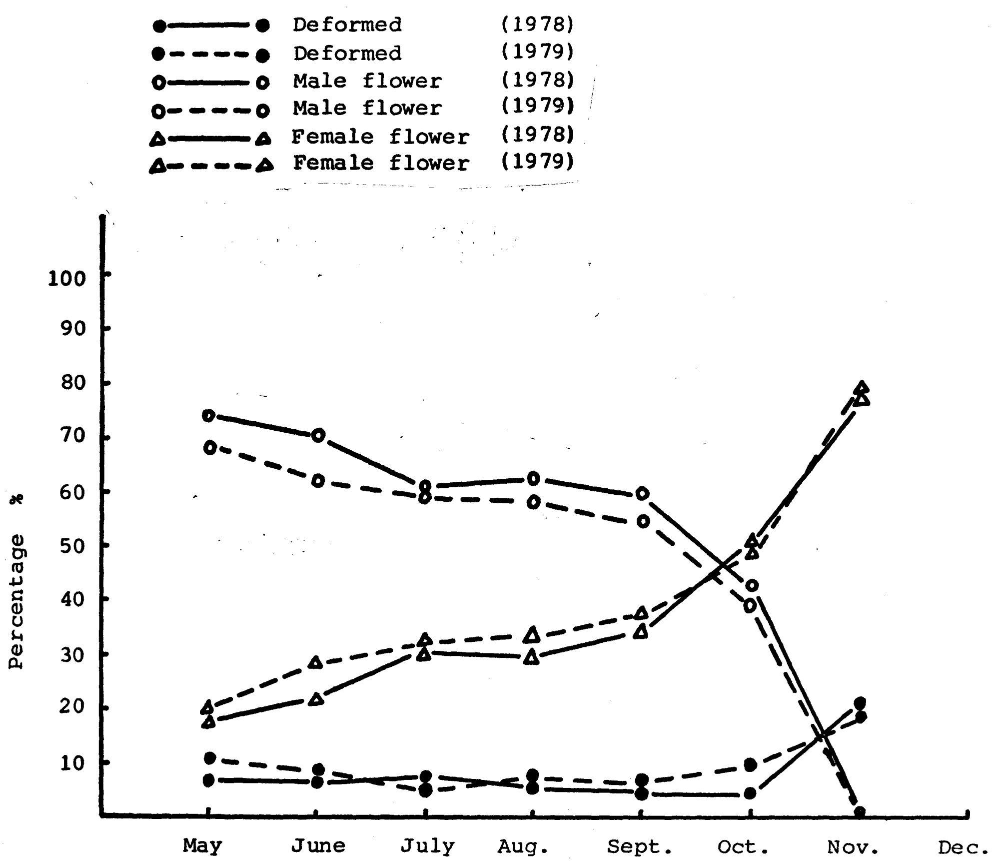


Fig. 8. Monthly variation in percentage of deformity, male and female flowers per panicle of coba in 1978 and 1979.

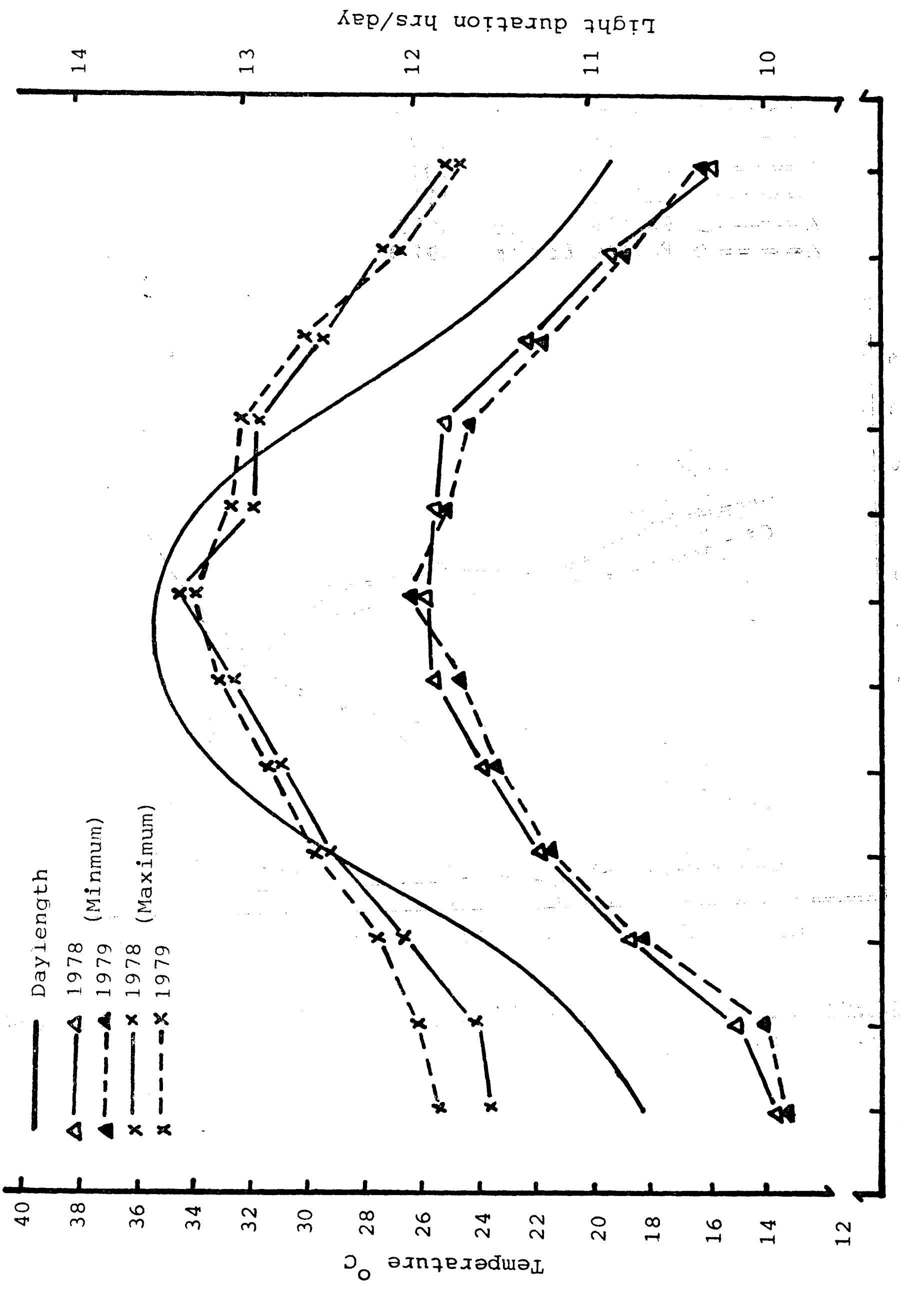


Fig. 9. Daylength variation in Kaohsiung area and monthly temperature variation in 1978 and 1979.

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季節變異對茭白花性表現之影響[1]

劉 政 道[2]

摘　要

青殼品種茭白在臺灣南部地區於5～11月間陸續抽穗開花，雌雄同株異花，雌花與雄花混生在同一花序中，花序是由多數小穗狀花序集合而成之大型圓錐花序，雄花主要着生於花序下部之小穗，雌花則以着生於上部之小穗爲主，花穗之長度、花穗節間長度、側花穗長度、側花穗數目、總花數、退化花數、雄花數、雌花數及雄花／雌花比均隨開花月份之不同發生明顯之變化，花穗長度、花穗節間長度及側花穗長度於5－9月份開花者，差異不明顯，10月份以後開花者，則明顯的下降，側花穗數目、總花數、退化花數、雄花數及雌花數均自5月份起有明顯之增加趨勢，至8或9月份最多，以後急劇下降，雄花／雌花比亦自5月份開花之最高而後逐漸減少，5月份開花者之比例約爲4：1，7月與8月份開花者之比例大致相似，約爲2：1，10月份開花者約爲1：1，至11月份開花者，花穗上極少雄花甚或完全沒有雄花着生，僅呈現雌花之現象。

1.臺灣省農業試驗所　研究報告第1081號。本文承蒙沈分所長再發，亞洲蔬菜研究及發展中心郭博士忠吉、林主任昭雄斧正，特此深致謝忱。

2.本所鳳山熱帶園藝試驗分所　助理研究員。臺灣省　高雄縣　鳳山市。

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Physiological Races of *Phakopsora pachyrhizi* in Taiwan [1]

C. C. Yeh[2]

ABSTRACT: Soybean cvs. Ankur, TK 5, TN4, and P.I.'s 200492 and 230971 are suggested as differentials for race identification of *Phakopsora pachyrhizi* causing soybean rust in Taiwan. Three races of *P. pachyrhizi*, based on lesion type, were identified among 50 sngile uredial cultures from soybean leaves collected at five locations in Taiwan. Reaction was determined 14 days after inoculation on intact leaves on plants as well as on detached leaves. The distribution of the three races varied among locations. Common bean, cowpea, hyacinth bean, lima bean, pigeon pea and yam bean also were tested but because no difference in lesion type was observed they were not used as differentials.

Phakopsora pachyrhizi H. & P. Sydow, the cause of soybean rust, was reported on 87 hosts (15). The different reaction of many hosts to infection by the fungus suggests the presence of different races (4,6,7,8,11,12,13). Lin (5) showed that collections of *P. pachyrhizi* from soybean varied in pathogenicity and virulence among non-soybean hosts. Two races of *P. pachyrhizi* were observed at the Asian Vegetable Research and Development Center (AVRC) Taiwan (14) but not confirmed. Two infection types on soybean leaves were suspected to indicate different races of *P. pachyrhizi* (2,9,10). Bromfield (1,2) demonstrated at least two races from Australia based on containment glasshouse studies. Using differential reactions of four soybeans inoculated with uredospores collected from different countries, Bromfield (3) identified four races of *P. pachyrhizi*. The uredospores used by Bromfield were collected with cotton swabs and maintained on Wayne soybean leaves in the glasshouse. Yeh (unpublished) observed two lesion types on the soybean leaves of P.I.'s 200492 and 230970 used in Bromfield's (3) studies, and on TK 5 and Shih-Shih when inoculated with uredospores obtained from soybean plants in the field at Taiwan Agricultural Research Instituts(TARI). Thus, race identification of *P. pachyrhizi* is confusing because no standardized scheme has been developed. In this study, five soybean cultivars and seven leguminosae species were inoculated with 50 single-uredial cultures of *P. pachyrhizi* for investigation of the presence of races of the fungus in

1. Contribution No. 1050 from Taiwan Agricultural Research Institute (TARI).
2. Plant Pathologist, Department of Plant Pathology, TARI, Wufeng, Taichung 431, Taiwan, Rep. of China.

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Materials and Methods

Plant tested

The following plants were grown in the glasshouse in pots containing pasteurized sandy loam : common bean (*Phaseolus vulgaris* L. cv. 5-Inch), cowpea (*Vigna ungnicu-lata*(L.) Walp. cv. Early Ramshorn), hyacinth bean (*Lablab purpureus* L. local), lima bean (*Phaseolus lunatus* L. localh), mungbean (*Vigna radiata*(L.) Wicz. local), pigeon pea (*Cajanus cajan* Millsp. local), yam bean (*pachyrhizus erosus* Urb. local) and soybeans ((*Glycine max*(L.) Merr. cvs. Ankur, TK 5, TN 4, Shih-Shih, P.I.'s 200492 and 230971).

Collection and purification of inoculum

Phakopsora pachyrhizi-infected soybean leaves were collected at Taiwan Agricultural Research Institute (TARI)cv. TN 4 ; the Asian Vegetable Research and Development Ceter (AVRDC) cv. TK 5 ; Pingtung cv. Shih-Shih ; Hualien cv. Shih-Shih ; and Taitung cv. Shih-Shih (Fig. 1). The leaves were washed gently with running tapwater, blotted with absorbent tissues to remove excess moisture and release old uredospores, and then sealed in transparent plastic bags. Freshly produced uredospores were obtained after 24 to 48 hrs at room temperatures (20-30 C).

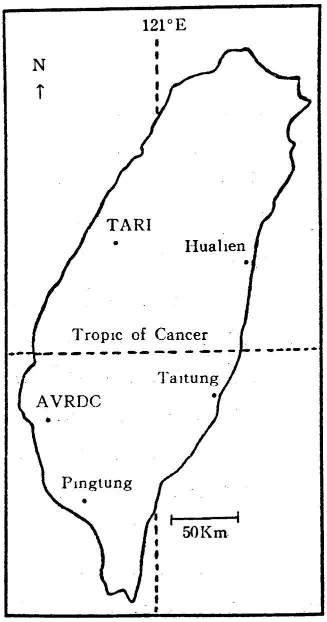

Fig. 1. *Phakopsora pachyrhizi* collection sites in Taiwan. (TARI=Taiwan Agricultural Research Institute, Taichung ; AVRDC=The Asian Vegetable Research and Development Center, Tainan.

Soybean leaves of the same cultivars from which the fungus was originally collected were detached from noninoculated glasshouse-grown plants, washed, blotted and placed, with the lower surface upward, in sterile culture plates (9-cm) containing a layer of

cotton in the bottom and covered with filter paper (Whatman No. 1) saturated with distilled water. A suspension of the freshly produced uredospores (ca. 5,000 spores/ml) prepared from distilled water plus Tween 80 (ca. 80 ug/ml) of each collection was sprayed on the leaves and the culture plates with sprayed and nonsprayed (control) leaves were placed on a bench next to a window at room temperatures (20-30 C) .

After 2 weeks, 10 single uredia from each of the five collections were selected randomly and the uredospores were removed from each uredium separately, using separate sterile camel's brushes for each uredium. Uredospores of each of the 50 isolates were inoculated and maintained on detached leaves of the same cultivar from which they were removed for three to four generations until sufficient uredospores were obtained for testing.

Inoculation

Leaves on intact plants were inoculated in pots and detached leaves in culture plates as previously described. Leaves of each plants were inoculated separately with an uredospore suspension (ca. 20,000 spores/ml) obtained from the 50 single uredial isolates of *P. pachyrhizi.* The inoculated plants were removed from moist chamber after 24 hrs and kept in the glasshouse (20-31 C) for observation. The detached leaves in the culture plates were placed on the bench in the laboratory as described previously. The infection lesion type on both sets of leaves were recorded 2 weeks after inoculation.

Results and Discussion

Two different infectton types, TAN and reddish-brown (RB) [2,10], were observed 14 days after inocualtion. TAN-type lesions usually sporulated heavily, with 3 to 5 uredia per lesion. RB-type lesions produced less uredospores and with 0 to 2 uredia per lesion. This is the first report on identifying races of *P. pachyrhizi* in which inoculum of each isolate was multiplied from single uredium. Thus, no mixed lesion types were observed (Fig. 2) as reported by the other workers [10] and the author's studies (unpublished) at TARI. The mixed infection types on a soybean leaf were due to the presence of races of the fungus in the inoculum. Based on the differential reaction on the five soybean cultivars, three races of *P. pachyrhizi* from soybeans were identified. Race 1 produced TAN-type lesions on all soybean cultivars ; Race 2 produced RB-type lesions only on P.I. 230971 and TAN-type on the other four cultivars ; Race 3 produced TAN-type lesions on P.I. 200492 and RB-type on the other four cultivars (Table 1, Fig. 2). All 50 single uredial isolates produced TAN-type lesions on common bean and yam bean ; and RB-type on cowpea, hyacinth bean, lima bean, mungbean, and pigeon pea. Because no difference in lesion types was observed among these leguminosae species, they are not currently suggested as differentials in this study. They may be considered, however, in the future as they also have shown with different reactions [8,12,13].

For identification of the three races, only two soybean cultivars, P. I. 230971 and each one of the following : TK 5, TN 4 or Ankur, are necessary. However, considering the limited number of samples in this study and the observation of different reaction types on three other soybean cultivars [4,7,11], all five soybean cultivars are tentatively suggested as differentials.

Fig. 2. TAN (left) and RB (reddish-brown) (right) type of lesions of soybean rust caused by race 1 and 2, respectively, of *Phakopsora pachyrhizi* on P.I. 230971 soybean leaf.

Table 1. Reaction of the three races of *Phakopsora pachyrhizi* on five soybean cultivars.

Soybean cultivar	R ·ce		
	1	2	3
Ankur	TAN[a]	TAN	RB
TN 4	TAN	TAN	RB
TK 5	TAN	TAN	RB
P.I. 230971	TAN	RB	RB
P.I. 200492	TAN	TAN	TAN

a Lesion type : TAN=tan color lesion ; RB=reddish—brown.

The distribution of the three races varied among locations. Race 1 was common at AVRDC and Race 2 at TARI and Taitung. Race 1 and 2 were present in about equal populations at Pingtung and only two isolates of Race 3 were obtained in the Hualien collection (Table 2, Fig. 1). When more collections are made at different locaations and in different years, more races may be identified.

Table 2. Distribution of the 50 singlle uredial isolates of *Phakopsora pachyrhizi* collected at five locations in Taiwan.

Location[a]	Race		
	1	2	3
TARI	2	8	0
AVRDC	9	1	0
Pingtung	5	5	0
Taitung	0	10	0
Hualien	0	8	2

a TARI=Taiwan Agricultural Research Institute, Taichung; AVRDC=The Asian Vegetable Research and Development Center, Tainan, Taiwan.

Acknowledgmenst

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臺灣大豆銹病菌生理小種之鑑定[1]

葉 忠 川[2]

摘 要

從農試所、亞蔬中心、屏東、臺東及花蓮等五個地區之大豆銹病標本，利用離葉法在培養皿內進行接種源之純化與繁殖，每個地區各分得十個單一夏孢子堆來源之菌株，將五十個菌株之夏孢子懸浮液以離葉法分別接種在大豆鑑別品種 Ankur, TK 5, TN 4, P.I. 200492 及 P.I. 230971上，在室內(20—30 °C) 經過二星期後，按病斑型可區分爲三個生理小種，此三個生理小種在植株上之反應與離葉法者相同，生理小種1在所有鑑別品種上產生感病型反應(TAN)；生理小種2僅在 P.I. 230971 上產生抗病型反應 (RB)，其餘均爲感病型；生理小種3則僅在 P.I. 200492 上產生感病型反應，其餘爲抗病型，此三個生理小種在五個地方之分佈不盡相同，臺東及花蓮未分離到生理小種1；生理小種2在五個地區均有發現；生理小種3僅在花蓮分離到二菌株。50個菌株在菜豆（四季豆）及豆薯上均產生感病型反應，而在豇豆 (cowpea)，鵲豆 (hyacinth bean)，皇帝豆（萊豆）及樹豆 (Pigeon pea) 上均產生抗病型反應，所以沒有被選用爲鑑別品種，但在將來的試驗或世界其他地區也許可以利用。

1.臺灣省農業試驗所 研究報告第1050號。
2.本所植物病理系副研究員。臺灣省 臺中縣 霧峰鄉。

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The Infestation and Control of Bulb Mite (*Rhizoglyphus robini*) on Gladiolus[1]

Chin-ling Wang[2]

Abstract : Bulb mite (*Rhizoglyphus robini* Claparede), the most serious pest on gladiolus, attacks gladiolus corms both in the field and in storage. About 78.6%, 90.0%, 80.0% and 54.2% of the gladiolus corms were found to be damaged by this mite when the plants were at 5-leaf, 7-leaf, corm-mature and corm-harvest stage, respectively. The number of mites found on the damaged corms in the field ranged from 4 to 540. During the corm storage period, 97.9% of the animal pests was the bulb mite. Only 55.5% of the corms were left healthy after stored for three months under laboratory conditions (15-28°C, 51-87% RH).

Dip treatment and fumigation treatment were tested for the control of the bulb mite. In dip treatment, chlorobenzilate, dicofol, tetradifon, triazid, azide, propargite, oxythioquinox, cyhexatin, bromopropylate, benzomate, cycloprate, azinphos-methyl, mecarbam, methyl demeton, methomyl, carbofuran, drawin, and oxamyl were tested. Of them, bromopropylate, benzomate, and methyl demeton had the best control effect on bulb mite. Fumigation of the bulb-mite-infested corms with 55% aluminum phosphide tablet (1 tablet : 3 gram) at the dosage of 1 tab/m^3 for 48 hours killed all the bulb mites when the temperature in the fumigation container ranged from 25-38°C. The dosage increased to 2 tab/m^3 when the temperature in the container ranged from 15-20°C.

Results of the observations made in Hor-li, the main commercial gladiolus growing area in Taiwan, and on the experimental field of the Taiwan Agricultural Research Institute in Taichung during the past few years indicate that gladiolus corms were usually infested with the bulb mite (*Rhizoglyphus robini* Claparede)[8]. The attack of bulb mite on corms or bulbs of plants such as amaryllis, crocus, lily, tulip, narcissus, hyacinth, garlic and onion has been found to take place both in the field and in storage[3]. Usually, the infestation of bulb mite follows the physical damage of tissue caused by other insects, pathogens, nematodes, or mechanical injuries[1,2,3,4,7]. The existence of bulb mite hasten the decay and make corms or bulbs completely destroyed even when the corms or bulbs would otherwise stand a very good chance

1. Contribution No. 1082 from the Taiwan Agriciultural Research Institute.
2. Assistant Entomologist, Department of Applied Zoology, TARI, Wufeng, Taichuag Hsien, Taiwan 431, Republic of China.

of recovery[3]. The injuries caused by this mite appears much more serious than any other pests so far known to attack the gladiolus corms[8]. Once infested with the bulb mite, the plant growth is greatly checked. Plants turn to yellow and present a general sickly appearence. The leaves of such plants are stunted and distorted, and the plant will generally fail to produce flowers or will produce only misshapen ones[6].

Field surveys and laboratory observations were made at TARI in 1981 and 1982 to study the occurrence and infestation of the bulb mite on stored gladiolus corms as well as the corms of growing gladiolus in the field. Besides, Trials were carried out to evaluate the effectiveness of certain chemicals for the control of this pest.

Methods and Materials

I. Survey of infestation in field and in storage

Studies on field infestation of bulb mite on gladiolus corms were made at four seperated gladiolus nurseries with plants at various growth stages from 35 to 92 days after planting. Samplings were made by randomly dug out 40 gladiolus corms from each nursery. These corms were then bring back to laboratory for evaluation of percentage of damage. The bulb mite on the corms were collected by placing these corms in cylinder extractor for 24 hours. The densities of the mite in four nurseries were calculated. The corms stored in laboratory under room conditions, 15-28°C and 51-87% RH, for three months from February 2 to May 4, 1982 were examined. The population of bulb mite and other pests on the stored corms and the damage of these corms were also investigated.

II. Control by dip treatment

Eighteen commercially formulated chemicals including chlorobenzilate, dicofol, tetradifon, triazid, azide, propargite, oxythioquinox, cyhexatin, bromopropylate, benzomate, cycloprate, azinphos-methyl, mecarbam, methyl demeton, methomyl, carbofuran, drawin, and oxamyl were tested. Chemicals were diluted to 1000, 2000, 4000 and up to 50000 times according to their active ingredient. Bulb mites were collected with a small soft brush and transferred in to a petri dish (dia. 5 cm). Diluted acaricides or insecticides were poured into these dishes, then the mites were immersed for 30 minutes or 60 minutes. At the end of dipping, the test mites were seperated from the poisoned fluid with a Bunnel's funnel; the mortality counts of the tested mites were made immediately. Each treatment was repeated three times. Bulb mite dipped in water for the same time was used as check. Influence of these chemicals on germination of the corms was observed.

III. Control by fumigation treatment

The corms infested with bulb mites placed in a air-tight container (1×1×1 m) were fumigated with 55% aluminum phosphide at different concentrations for varied period of time. The fumigation tests were conducted in May and June, 1981 when the temperature in fumigation container varied from 25-38°C, and in February, 1982 when the temperature in fumigation container ranged from 15-20°C. The bulb

mites on corms were examined using an anascope after fumigation, and the mortality counts were made. These corms were examined again seven days after fumigation to find whether there were any larvae or nymphs that have hatched from the eggs that were not destroyed by the previous fumigation.

Results

I. Survey of infestation in field and in storage

Corms collected from all four nurseries were from moderately to seriously infested with bulb mite (Table 1). This suggests that corms of gladiolus of all growth stages might be susceptable to the attack of bulb mite. Corms sampled from nurseries A, B, C where gladiolus were continuously planted for at least two seasons were observed to be infested by this mite at 78.6%, 90.0%, and 80.0%, respectively, whereas a newly planted field, nursery D, with rose as proceeding crop, had relatively lower percentage of infestation that was 54.2%. Number of mites found on the damaged corms in these nurseries ranged from 4 to 540 and the average ranged from 57.0 to 104.7 in various nurseries.

Bulb mite reproduced rapidly on laboratory stored corms. A total of 10,705 bulb mites were collected by cylinder extractor from 45 corms after storing for three months. The number of other insect pests such as *Drosophila* sp. , *Panafennis* sp. and beetles and moths was 225 which was only 2.1% of the bullb mites. There were 25 corms to be observed empty and dried out which were caused by bulb mite damage.

II. Control by dip treatment

One-thousand-time diluted chlorobenzilate, tetradifon, triazid, bromopropylate, benzomate, methyl demeton resulted in 100% mortality of bult mites under 30 minutes dipping (Table 2). For the same dipping period, completely killing of the pest was not observed with 2000 and 4000 times diluted chlorobenzilate, tetradifon, and triazid while for bromopropylate, benzomate and methyl demeton, 100% mortality was not obtained when diluted 4000 times. By further testing, we found that the lowest concentrations resulting in 100% mortality of bulb mite for bromopropylate, benzomate and methyl demeton was 30000, 4000, and 4000 dilution times, respectively (Figure 1).

Table 1. Survey of bulb mite infestation at four seperate gladiolus nurseries in TARI experimental farm and greenhouse, 1982.

Nursery	Proceeding crop	Days after planting	Plant growth stage	Bulb mite damaged corm (%) [a]	Avg. no. of bulb mite per damaged corm	
					Mean	Range
A	Gladiolus	23	5-leaf	78.6	57.0	6—540
B	Gladiolus	50	7-leaf	90.0	104.7	6—105
C	Gladiolus	73	corm-mature	80.0	79.7	4—340
D	Rose	92	corm-harvest	54.2	64.2	8—154

[a] forty corms were examined in each nursery

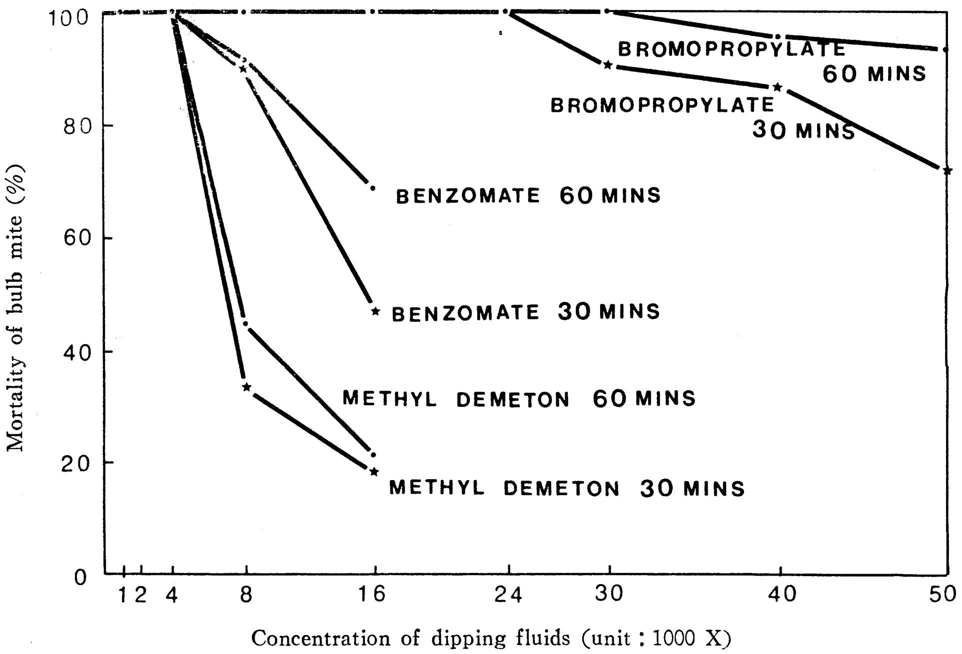

Figure 1. Comparison of the mortalities (%) of bulb mite after being dipped in various pesticide at various concentrations for 30 and 60 minutes.

Propargite, oxythioquinox, cyhexatin, cycloprate, mecarbam and carbofuran were not satisfied in controlling bulb mite. None of these chemical agents resulted in 100% mortality of bulb mite after both 30 and 60 minutes dipping (Table 2, 3).

Another set of trials revealed that germination ability of corm was not adversely affected by dipping treatment of any of the pesticides tested.

Table 2. Mean mortality (%) of bulb mite after being dipped in various pesticide for 30 minutes. [a]

Pesticide	Formulation	Conc. of dipping fluid					
		1000 X		2000 X		4000 X	
		Mortality	SE	Mortality	SE	Mortality	SE
Chlorobenzilate	25.5 EC	100.0	0.0	91.6	3.3	73.3	1.7
Dicofol	45 EC	93.9	5.6	81.6	6.5	60.0	8.0
Tetradifon	7.6 EC	100.0	0.0	89.8	0.3	75.0	2.9
Triazid	20 EC	100.0	0.0	96.6	1.7	88.3	6.0
Azide	55 EC	97.2	3.0	92.7	3.2	38.8	4.3
Propargite	57 EC	83.2	5.6	59.6	2.5	43.6	2.7
Oxythioquinox	25 WP	1.2	1.6	2.0	1.6	0.0	0.0
Cyhexatin	50 WP	66.6	4.4	66.6	7.3	70.0	10.4

Bromopropylate	20 EC	100.0	0.0	100.0	0.0	100.0	0.0
Benzomate	20 EC	100.0	0.0	100.0	0.0	100.0	0.0
Cycloprate	30 EC	63.3	16.9	65.3	11.1	34.0	11.6
Azinphos-methyl	20 EC	99.2	0.7	98.7	0.7	97.2	1.3
Mecarbam	35 EC	90.3	1.2	71.6	8.2	44.2	11.7
Methyl demeton	25 EC	100.0	0.0	100.0	0.0	100.0	0.0
Methomyl	24 EC	88.3	1.7	83.3	1.5	75.3	0.3
Carbofuran	25 WP	68.5	7.0	53.1	2.8	65.4	15.8
Drawin	50 EC	99.0	1.0	94.0	3.7	69.0	6.7
Oxamyl	24 EC	92.0	3.4	92.8	4.3	90.3	5.5

[a] Dipping fluid were prepared by diluting the pesticides 1000, 2000 and 4000 times to the active ingredient.
All the treatments were replicated 3 times.

Table 3. Mean mortality (%) of bulb mite after being dipped in various pesticide for 60 minutes. [a]

Pesticide	Formulation	Conc. of dipping fluid					
		1000 X		2000 X		4000 X	
		Mortality	SE	Mortality	SE	Mortality	SE
Chlorobenzilate	25.5 EC	100.0	0.0	100.0	0.0	78.3	1.7
Dicofol	45 EC	100.0	0.0	100.0	0.0	82.9	2.5
Tetradifon	7.6 EC	100.0	0.0	98.0	1.7	100.0	0.0
Triazid	20 EC	100.0	0.0	100.0	0.0	93.3	3.3
Azide	55 EC	100.0	0.0	91.4	4.8	85.7	4.0
Propargite	57 EC	74.6	15.8	57.7	5.1	22.3	20.1
Oxythioquinox	25 WP	3.3	4.4	0.0	0.0	6.3	2.7
Cyhexatin	50 WP	83.3	8.3	63.3	1.7	75.0	12.6
Bromopropylate	20 EC	100.0	0.0	100.0	0.0	100.0	0.0
Benzomate	20 EC	100.0	0.0	100.0	0.0	100.0	0.0
Cycloprate	30 EC	65.0	12.7	48.3	8.5	59.3	7.5
Azinphos-methyl	20 EC	100.0	0.0	100.0	0.0	97.9	1.0
Mecarbam	35 EC	88.0	2.0	80.9	7.8	43.7	17.0
Methyl demeton	25 EC	100.0	0.0	100.0	0.0	100.0	0.0
Methomyl	24 EC	96.0	4.7	96.6	3.7	81.7	7.3
Carbofuran	75 WP	54.1	1.0	60.8	23.7	55.2	6.4
Drawin	50 EC	100.0	0.0	93.0	4.9	91.4	3.9
Oxamyl	24 EC	97.1	2.4	91.1	4.8	70.1	1.7

[a] Dipping fluid were prepared by diluting the pesticides 1000, 2000 and 4000 times to the active ingredient.
All the treatments were replicated 3 times.

III. Control by fumigation treatment

Tests conducted in May and June of 1980 in the fumigation container where temperature varied from 25–38°C showed that fumigation of the infested corms with 55% aluminum phosphide tablet (1 tablet : 3 gram) at the rate of 1 tab/m³ for 24 hours did not give complete kill of the bulb mite, but when the dosage was increased to 2 tab/m³ or 4 tab/m³, 100% kill of the adult, nymphal and larval bulb mite was obtained. However, some of the eggs survived these treatments from which the larvae had hatched seven days later (Table 4). Fumigations of the corms with aluminum phosphide at the dosage of 1/2 or 1 tab/m³ for 48 hours also gave 100% kill of the adults and nympns and larvae. Following these 48-hour treatment, the treated corms were again examined seven days later ; only some newly hatched larvae were found on the corms treated with this chemical at the dosage of 1/2 tab/m³, while no living mites were found on the corms treated with the dosage of 1 tab/m³. The fumigated corms did not lose their germination ability.

Table 4. Effects of fumigation of 55% aluminum phosphide tablet on the control of the bulb mite on gladiolus corms when the temperature in fumigation container varied from 25–38°C.

Fumigation period	Dosage (tab/m³)	Avg . no. of bulb mite/corm[a]	
		One DAF[b]	Seven DAF
24 hours	1	284	225
	2	0	24
	4	0	0
48 hours	1/4	252	271
	1/2	0	102
	1	0	0

[a] Twenty corms were examined in each treatment
[b] DAF : day after fumigation

Tests were repeated in February of 1981 when the temperature on the container dropped to 15–20°C. The results indicated that to obtian 100% kill of all the stages of the bulb mite, the dosage had to be increased to 2 tab/m³ when the fumigation time being 48 hours (Table 5).

Table 5. Effects of fumigation of 55% aluminum phosphide tablet on the control of the bulb mite on gladiolus corms when the temperature in fumigation container varied from 15–20°C.

Fumigation period	Dosage (tab/m³)	Avg . no. of bulb mite/corm[a]	
		One DAF[b]	Seven DAF
48 hours	1/2	574	592
	1	33	29
	2	0	0

[a] Twenty corms were examined in each treatment
[b] DAF : day after fumigation

Discussion

Gladiolus corms harvested from field usually bring bulb mites which stay alive on stored corms and reproduce rapidly if the environment is favorable. Adaptable control measures of these bulb mites before planting would eliminate the possibility of their occurrence and infestation.

To decide which method should be adopted to control the bulb mite, one should consider the amount and the stage of the corms to be treated and the scheduled planting time. Dip treatment is convenient for corms in small amount and is suitable for the hibernated corms. Since the corms which have passed their hibernation period would germinate upon the contact of water in warm weather, once these corms are dipped, the following storage would be very difficult. Fumigation treatment can be applied at any stage of the corm and their subsquent storage is permissible.

All the data obtained in this experiment were based on the responses of the bulb mite in normal forms. Few hypopal nymphs were observed during the experimental period, their response to the chemicals were not included in this report.

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唐菖蒲球莖蟎 (*Rhizoglyphus robini*) 之爲害與其防治

王 清 玲[2]

摘 要

球莖蟎 (*Rhizoglyphus robini* Claparede) 爲唐菖蒲種球栽植時期與儲存時期爲害最嚴重之害蟎，田間栽植之唐菖蒲生育至 5 葉期、7 葉期、種球成熟期及種球收穫期分別有78.1%，90.0%，80.0%及54.2%之種球被球莖蟎爲害，被害球上之蟎數自 4 至540隻。種球在試驗室內 (15—28°C, 51—87%pH) 儲存 3 個月後，發現其上之有害動物有97.9%爲球莖蟎，健全種球僅餘44.4%。

防治球莖蟎之方法包括浸漬處理與燻蒸處理。浸漬處理共試驗了 18 種藥劑，包括 chlorobenzilate, dicofol, tetradifon, benzomate, cycloprate, triazid, azide, propargite, oxythioquinox, cyhexatin, bromopropylate, azinophos-methyl, mecarbam, methyl demeton, methomyl, carbofuran, drawin, oxamyl。其中以 bromopropylate, benzomate, methyl demeton 效果最優良。若以燻蒸處理，燻蒸箱溫度爲 25—38°C 時，以每立方公尺一片 (3 g) 之55% aluminum phosphide 燻蒸被害之種球48小時，可消滅所有之球莖蟎，當箱內溫度降至 15—20°C 時，用藥量應提高至每立方公尺 2 片。

1. 臺灣省農業試驗所　研究報告第1082號。本文曾受行政院國家科學委員會獎助。

2. 本所應用動物系助理研究員。臺灣省 臺中縣 霧峰鄉。

本省柑橘園土壤之酸性化與其酸性來源[1]

黃 文 良[2]

摘要：本省之柑橘園，經過長時間的裸露式耕耘與連年施用生理酸性肥料，其土壤之酸性化已到相當嚴重的程度。樹齡超過10年以上的柑桔園，除部分來自含石灰質較多母質者以外，多已示pH 4.2至4.9的强酸性反應，甚而有 pH 4 以下的極端酸性者。在已示强酸性反應的柑橘園中，明顯的土壤特性爲鹽基類的缺乏與交換性鋁的顯著增加。鋁離子飽和度，視石灰施用情形而異，但多已達40%至77%。鋁離子已取代鹽基而成爲主要的交換性陽離子。在酸性構成要因中，與土壤 pH最有關連者，乃爲置換酸度中佔79%至86%的三價鋁離子，在兩者間介有極顯著的負相關關係（r＝－0.81**）。在置換酸度中，其餘14%至21%爲交換性氫。由於土壤中累積有相當量的水溶性 SO_4^{--} 及 NO_3^-，有可能生成游離酸。交換性鐵，在柑園土壤中，僅有微量存在，不構成爲酸性來源。由此可知，本省柑橘園土壤的主要酸性來源爲鋁離子 $[Al(H_2O)_6]^{3+}$，經年累積結果，使得大多數柑橘園的土壤反應已降至 pH 4.2 至 5.2，即鋁離子的緩衝能範圍，並依鋁離子及鹽基性鋁離子含量的多寡，顯示其 pH 值。

據臺灣農業年報[1)]的統計資料，本省柑橘類的種植面積，在民國 63／64 年達最高以後，有逐年顯著減少的趨勢。以民國69年的種植面積而言，晚崙西亞橙已減少65%；桶柑減少21%；椪柑亦減少12%。究其原因，當以柑橘立枯病的猖獗貽害爲要因以外，柑橘園長時間的不當土壤肥培管理所引起的土壤酸性化，直接或間接影響柑橘的生長與壽命，終致廢耕，亦爲原因之一。關於本省柑橘園的土壤酸性化問題，各方早就有所指摘，並建議施用適量石灰質肥料予以矯正。但不僅未見改善，甚而每可見及其生產應屬最旺盛的10～20年生柑橘園，由於土壤的極端酸性化，已呈現樹勢未老先衰，柑葉變細小，異常黃化落葉，果實變小，產量劇減等各種衰敗現象。吾人已知，本省柑橘園的土壤酸性化，已到相當嚴重的程度，但其酸性來源，已知甚少。

本研究，即於全省主要柑橘生產地，選取樹齡已超過10年以上的柑橘園，採集代表剖面土壤樣本，供爲試驗材料，以探討土壤酸性化程度與酸性構成要因。茲將所得結果報告於後，以資柑橘園土壤肥培管理改善的參考。

材料與方法

一、代表柑橘園土壤樣本之採集

在全省主要柑橘產地，選取樹齡已有10年以上的柑橘園共11處，採集代表剖面土壤樣本。各採樣地點的柑橘種類、樹齡、土壤及栽培環境如表１。

1.臺灣省農業試驗所 研究報告第1083號。
2.本所農業化學系副研究員。臺灣省 臺中縣 霧峰鄉。

表1. 本省主要柑橘產地代表果園之概況

Table 1. General description of the representative orchards of major citrus producing areas of Taiwan

土壤代號 Soil No.	地　點 Sampling location	柑橘種類 Species	樹齡（年） Age	地形、母質及土壤 Topography, parent rocks, & soils
1	宜蘭縣員山鄉崩圳頭	桶　柑	15	邱陵地板岩母質黃壤
2	臺北縣石碇鄉火燒樟	桶　柑	20	邱陵地砂岩頁岩母質黃壤
3	陽明山平等里	桶　柑	12	岡丘地安山岩母質暗色土
4	新竹縣寶山鄉	椪　柑	12	低邱陵地砂岩頁岩母質黃壤
5	新竹縣關西鎮東安里	椪　柑	18	洪積層台地紅壤
6	苗栗縣卓蘭鄉大坪	椪　柑	20	洪積層台地紅壤
7	臺中縣東勢鎮大茅埔	椪　柑	47	邱陵地砂岩頁岩母質黃壤
8	嘉義縣梅山鄉雙溪	椪　柑	25	台階地老冲積土
9	臺南縣玉井鄉	柳　橙	15	新冲積土
10	臺東縣班鳩工作站	晚侖西亞橙	27	邱陵地山麓片岩崩積土
11	臺東縣泰源鄉北源村	晚侖西亞橙	25	安山岩母質老冲積土

二、土壤分析

土壤反應，以玻璃電極 pH 計，分別檢定 H_2O (1：1) 及 KCl (1：2.5) 之 pH 值。置換酸度之測定，將供試土壤對中性 N-KCl 液 1：2.5 浸出七次，取浸出液 50 ml，應用 Yuan 滴定法 [10]，滴加 phenolphthalein 爲指示劑，以 N/20 NaOH 液滴定之，以求置換酸度。交換性鋁、鐵及氫之測定，取 N-KCl 浸出液 50 ml，加 4 % NaF 液 5 ml，滴加 phenolphthalein 爲指示劑，以 N/20 NaOH 液滴定，以先求交換性氫量。交換性鋁量則由置換酸度與交換性氫量間之差得之。交換性鐵量，另取 N-KCl 浸出液 20 ml，應用 O-phenanthroline 比色法測定之。交換性鈣及鎂量，仍用 N-KCl 浸出液，以 Versene 滴定法測定之。總酸度之測定，應用 Peech 法 [8]，以 pH 8.0 的 0.5 N $BaCl_2$-0.055 N Triethanolamine 緩衝液 1：10 浸出後，以 0.2 N HCl 液滴定得之。N-KCl 浸出液之滴定曲線，取浸出液 50 ml，先以不含 CO_2 的空氣加予通氣10分鐘，以驅除試液中含有之碳酸，然後應用自動攪拌器一面予以攪拌，一面應用玻璃電極 pH 計爲指示器，以 N/20 NaOH 液滴定，繪成滴定曲線。水溶性 NO_3^- 之測定 [5]，取 50 g 土壤，先以含有 N-$CuSO_4$ 液 5 ml 之水 250 ml 加予振盪浸出，抽取 125 ml 上澄液，然後添加 0.2 gCa $(OH)_2$ 及 0.5 g $MgCO_3$ 再予振盪浸出，得澄清浸出液，應用擴散法 [2]，加硫酸第一鐵與鋅粉予以還元測定之。水溶性 SO_4^{--} 之測定，應用 $CaSO_4$ 法 [5]，以 1：10水抽出後，添加 $CaCl_2$ 及丙酮使之沉澱爲 $CaSO_4$，再以丙酮加洗一次，然後加水使之溶解，應用 Versene 滴定法測定 Ca 以求 SO_4^{--}。水溶性磷之測定 [5]，水浸出液普通包含正磷酸（orthophosphate）及重合磷酸（poly-phosphate）以 1：10水抽出後，應用鉬藍比色法測定之。

結　果

一、柑橘園土壤之酸性化

據表 2，供試園之土壤反應（水懸濁液 1：1），來自石灰質含量較多母質的泰源柑園土壤呈現 pH 5.9 至 6.5 之微酸性至中庸酸性反應，另玉井柑園表土及寶山柑園底土，因施用石灰質肥料關係

而呈現 pH 5.25 至 5.5 强酸性反應以外，其餘大多數供試園，無論土壤種類，均為 pH 4.6 至 4.9 之極强酸性反應。部分柑園，如石碇及卓蘭表土已降至 pH 4.3 至 4.4，東勢表底土則甚而劇降至 pH 3.5 至 3.7，呈現極端酸性反應。另以 KCl 之土壤懸濁液（1 ：2.5）檢定 pH 值，大多數供試園均介於 pH 3.7 與 4.0 之間，仍屬於極强酸性至强酸性反應。東勢柑園土壤之 KCl 懸濁液 pH 值為 3.4 至 3.5 之極强酸性反應。

二、柑橘園土壤之鹽基溶脫

表 2 示，本省柑橘園土壤，普遍缺乏可交換性鹽基而相對的增加交換性鋁。Shofield[9] 將粘土的置換基分為來自永久負電荷（permanent negative charge）與依靠 pH 變化的附加負電荷（additional negative charge）。據 Coleman 等[6]，酸性土壤中粘土的永久負電荷可吸附或置換鹽基離子，鋁離子及氫離子，而以中性的强酸鹽可置換浸出的鈣、鎂、鋁及氫離子量之總和，大略等於土壤中永久負電荷的置換基量。在柑園土壤中，以中性的氯化鉀液可提溶的交換性鈣、鎂、鋁及氫離子

表2. 供試柑橘園土壤的 pH，交換性鈣、鎂、鋁、氫量與其飽和度

Table 2. Soil pH, exchangeable bases, aluminum and hydrogen content, and their saturation degrees of applied citrus orchards.

土壤代號 Soil No.	地點 Location	深度 Depth (cm)	pH		Cations absorbed by p-charge CEC me/100g				p-charge CEC me/100g	Base Sat'n %	Al Sat'n %
			H_2O	KCl	Ca	Mg	Al	H			
1	員山	0—19	4.8	3.9	1.52	0.42	4.08	0.88	6.90	28.12	59.13
		39—60	4.55	3.9	0.21	0.38	4.13	0.95	5.67	10.41	72.84
2	石碇	0—18	4.3	3.9	0.31	0.13	3.47	0.58	4.49	9.80	77.28
		28—46	4.6	4.0	0.51	0.52	3.74	0.92	5.69	18.10	65.73
3	陽明山	0—9	4.6	3.7	2.57	1.41	2.65	0.69	7.32	54.37	36.20
		9—24	4.7	4.0	3.64	0.28	3.23	0.79	7.94	49.37	40.68
4	寶山	0—20	4.75	3.7	2.66	3.69	2.70	0.55	9.60	66.15	28.13
		20—50	5.25	3.8	2.45	4.10	2.08	0.40	9.03	72.54	23.03
5	關西	0—15	4.7	3.8	2.27	0.31	2.73	0.50	5.81	44.41	46.99
		26—45	4.6	4.0	1.17	0.17	4.10	0.77	6.21	21.58	66.02
6	卓蘭	0—20	4.4	3.9	0.72	0.26	3.50	0.56	5.04	19.44	69.44
		36—61	4.7	4.0	0.31	0.15	3.54	0.55	4.55	10.11	77.80
7	東勢	0—12	3.7	3.4	1.32	2.58	4.74	1.02	9.66	40.37	49.07
		28—50	3.5	3.5	1.13	0.40	8.34	1.26	11.13	13.75	74.93
8	梅山	0—25	4.6	4.0	0.60	0.31	1.86	0.41	3.18	28.62	58.49
		25—50	4.6	4.0	0.61	0.28	2.02	0.33	3.24	27.47	62.35
9	玉井	0—20	5.5	4.3	2.62	0.45	0.38	0.04	3.49	87.97	10.89
		20—50	4.9	3.9	2.13	0.54	2.18	0.55	5.40	49.44	40.37
10	斑鳩	0—18	4.9	4.0	2.25	0.74	1.37	0.50	4.86	61.52	28.19
		36—51	4.7	4.0	0.61	0.58	2.13	0.56	3.88	30.67	54.90
11	泰源	0—18	6.5	4.6	10.34	2.72	0	0.38	13.44	97.17	0
		33—58	5.9	5.6	12.62	0.99	0	0.24	13.85	98.27	0

，即係於現地的土壤 pH 條件下，由永久負電荷置換基所吸着者。因此，若將供試園土壤的交換性鹽基與鋁量，以永久負電荷的置換基中所佔百分率表示其鹽基飽和度與交換性鋁飽和度，則應更能看出土壤鹽基溶脫與交換性鋁離子之聚積狀況。各供試園土壤，依石灰質肥料的施用情形，顯示不同程度的鹽基飽和度。但由大多數柑園底土中的低鹽基飽和度，仍不難看出其鹽基溶脫的嚴重性。同時在土壤 pH 值與鹽基飽和度間可見極顯著的正相關（r=0.748**）。在供試園中，來自石灰母質而呈微酸性至中庸酸性反應的泰源柑園土壤幾達鹽基飽和；因石灰質肥料施用而呈現强酸性至極强酸性反應的玉井、寶山、班鳩等柑園，其表土的鹽基飽和度在於 61% 與 88% 間，底土為31%至72%；陽明山、關西、梅山、員山等呈極强酸性反應的柑園表土為22%至 54%，底土為 10% 至 49%；呈極端酸性的東勢、石碇、卓蘭等柑園表土為 10% 至 40%，底土為 10% 至 18%。

三、柑園土壤中鋁離子之聚積

由表 2 可知，柑園土壤中之交換性鋁量與 pH 之間的關係。如泰源柑園之土壤 pH 值在 6.0 左右時，尙無交換性鋁離子的存在。當土壤 pH 值降至 5.5 時，則如玉井柑園，可發現痕跡的交換性鋁離子產生。土壤 pH 值在 5.0 左右時，交換性鋁離子量就會顯著的增加。若土壤 pH 值繼續減低時，交換性鋁離子就隨之大量增加。此表示，酸性柑園土壤的 pH 值愈趨低，在土壤中所產生的鋁離子量會愈多，隨而會取代原被土壤的永久電荷之置換基（來源於 P-charge 之陽離子交換能量）所吸附的鹽基離子，變成主要的交換性陽離子。土壤 pH 值與交換性鋁量之間的相關關係如圖 1，在兩者間有極顯著的負相關（r=−0.81**）。同時，供試園土壤的交換性鋁飽和度與 pH 之間也有極顯著的負相關關係（r=−0.75**）。若土壤 pH 值為 5.5 時，其交換性鋁飽和度為 11% 左右。土壤 pH 值在 4.9 至 5.2 之間則為 23% 至 40%。土壤 pH 值在 4.8 以下時，交換性鋁飽和度就隨而增大，而在於 28% 與 78% 之間。

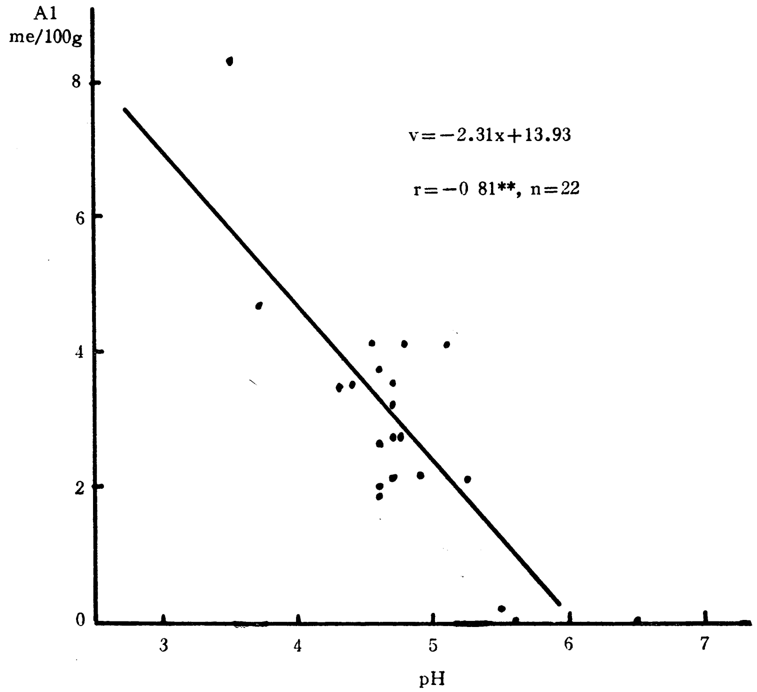

圖1. 柑橘園之土壤pH與置換性鋁量間關係

Fig. 1. Relationship between soil pH and exchangeable aluminum content of citrus orchards.

四、柑園土壤的酸度要因

據吉田等[3],[4]，礦質酸性土壤的氫離子來源，包括有1）由粘土的永久負荷電以靜電所吸附的交換性氫離子，以及經由交換性鋁及鐵的加水分解產生的氫離子，均屬置換酸度（Exchange acidity），2）經由粘土吸着固定而非交換性的鹽基性鋁離子（hydroxyl aluminum）起加水分解產生的氫離子，3）由土壤的附加負荷電所吸附而隨 pH 昇高解離的氫離子，即 pH 依靠酸度(pH-dependent acidity）。其中，交換性氫、鋁、鐵及鹽基性鋁離子，皆係由强酸型的永久負電荷（P-charge）之置換基所吸着。隨 pH 昇高而增加解離的交換性氫則係由弱酸型的附加負電荷（a-charge）所吸着。表3即示，供試園土壤的各酸度要因分析結果。總酸度係各酸性容量因子的總量。因各酸度因子的活性程度不同，供試園土壤的總酸度大小則不一定與 pH 值產生直接關係。在各酸度中，置換酸度爲强酸型的酸度要因，在置換酸度與土壤 pH 間可發現極密接的負相關關係（r = −0.81**）。置換酸度

表3. 供試柑園土壤之酸性要因

Table 3. Acid components of applied citrus orchard soils.

土號 Soil No.	地點 Location	深度 Depth (cm)	pH (H_2O)	總酸度 Total acidity me/100 g	置換酸度 Exchange acidity me/100g	交換性鹽基性鋁及附加荷電酸度 Exch. hydroxyl Al & a-charge acidity me/100 g
1	員山	0—19	4.8	17.02	4.96	12.06
		39—60	4.53	13.76	5.08	8.68
2	石碇	0—18	4.3	16.72	4.05	12.67
		28—46	4.6	11.91	4.66	7.25
3	陽明山	0— 9	4.6	19.38	3.34	16.04
		9—24	4.7	20.18	4.02	16.16
4	寶山	0—20	4.75	10.39	3.25	7.14
		20—50	5.25	8.59	2.48	6.11
5	關西	0—15	4.7	10.90	3.22	7.68
		26—45	5.1	9.14	4.87	4.27
6	卓蘭	0—20	4.4	15.06	4.06	11.00
		36—61	4.7	13.58	4.09	9.41
7	東勢	0—12	3.7	11.81	5.76	6.05
		28—50	3.5	14.04	9.60	4.44
8	梅山	0—23	4.6	6.72	2.27	4.45
		23—50	4.6	8.16	2.35	5.81
9	玉井	0—20	5.5	3.05	0.42	2.63
		20—50	4.9	5.92	2.73	3.19
10	班鳩	0—18	4.9	9.76	1.87	7.89
		36—51	4.7	11.34	2.69	8.65
11	泰源	0—18	6.5	5.67	0.38	5.29
		33—58	5.9	5.80	0.24	5.56

的主要酸性物質為交換性鋁、鐵、氫以及水溶性酸。供試園土壤中的交換性鐵，僅以痕跡量存在，因而不會成為酸性來源。交換性鋁量，在强酸性柑園土壤中均含有置換酸度的 79% 至 86%，係屬置換酸度中最重要的構成要因。其餘 14% 至 21%，則係屬交換性氫或水溶性酸，亦為酸性柑園土壤中甚重要的酸性來源。柑園土壤中水溶性硝酸、硫酸及磷等强酸根陰離子分析結果如表 4 。經連年施用硫酸錏、硫酸鉀等生理酸性肥料後，各供試園土壤中已聚積相當量的硝酸或硫酸根，顯示强酸性柑園土壤中可能生成可溶性酸，會破壞粘土而產生鋁離子，隨而逐漸降低土壤 pH。

表4. 供試柑園土壤中水溶性 NO_3^-, SO_4^{--} 及 P 含量

Table 4. Water-soluble NO_3^-, SO_4^{--} and P content of applied citrus orchard soils.

土號 Soil No.	地點 Location	深度 Depth (cm)	NO_3^- ppm	SO_4^{--} ppm	P* ppm
1	員山	0—19	328	178	11.8
		39—60	113	84	4.9
2	石碇	0—18	228	112	3.0
		28—46	202	58	2.0
3	陽明山	0— 9	284	128	4.4
		9—24	253	173	4.0
4	寶山	0—20	217	68	3.9
		20—50	184	72	3.6
5	關西	0—15	224	78	1.9
		26—45	76	79	0.2
6	卓蘭	0—20	149	38	5.2
		36—61	126	36	3.6
7	東勢	0—12	401	87	1.9
		28—50	520	69	0.3
8	梅山	0—25	103	58	4.7
		25—50	92	52	1.8
9	玉井	0—20	130	85	4.7
		20—50	167	46	7.1
10	班鳩	0—18	113	168	2.0
		36—51	110	68	0.5
11	泰源	0—18	110	194	3.8
		33—58	58	137	2.1

*Including ortho-phosphate and polyphoshate.

圖 2 示，將供試園土壤的中性 KCl 浸出液，以 NaOH 液滴定所繪成的滴定曲線，由滴定曲線的形狀，凡屬於强酸性柑園土壤者，其滴定曲線可分為兩個階段。第一階段，即由滴定剛開始時短暫的劇昇以後，保持較平坦的直線部分。依其形狀及位置可推定，其緩衝域介於 pH 4.2 與 5.4 之間，係 Al^{3+} 或其重合體 $[Al(OH_2)_6]^{3+}$ 經由加水分解產生的氫離子之中和反應。供試園土壤中之交換性

鋁離子量愈高，其平坦直線部分就愈往右拖長，表示其緩衝力愈大。本階段為滴定曲線中最主要的部分，各供試園土壤浸出液滴定至 pH 5.4 的 NaOH 毫當量則平均佔滴定至 p H 8.0 的 NaOH 毫當量的72%左右，其最終生成物可能為 $[Al(OH)_2]^+$ 至 $[Al(OH)_{2.5}]^{0.5+}$ 的鹽基性鋁離子。圖 2 又示，土壤酸度愈强，其 KCl 浸出液的 pH 值愈低，並滴定至 pH 4.2 以前仍有消耗少量的 NaOH，顯示交換性鋁以外其他的氫離子來源。第二階段，即由 pH 5 左右的變曲點向上昇高部分，土壤中含鋁子量多時，上昇線就趨向於成傾斜之勢，且綿絮狀沈澱之生成亦增多， 本階段中滴定至 pH 8.0 的最終生成物為 $Al(OH)_3$ 。圖 2 又示，供試園土壤的 KCl 浸出液滴定曲線，概略依土壤 pH 值之高低順序，由左向右排列，顯示土壤 pH 值與交換性鋁量間的密接關連。

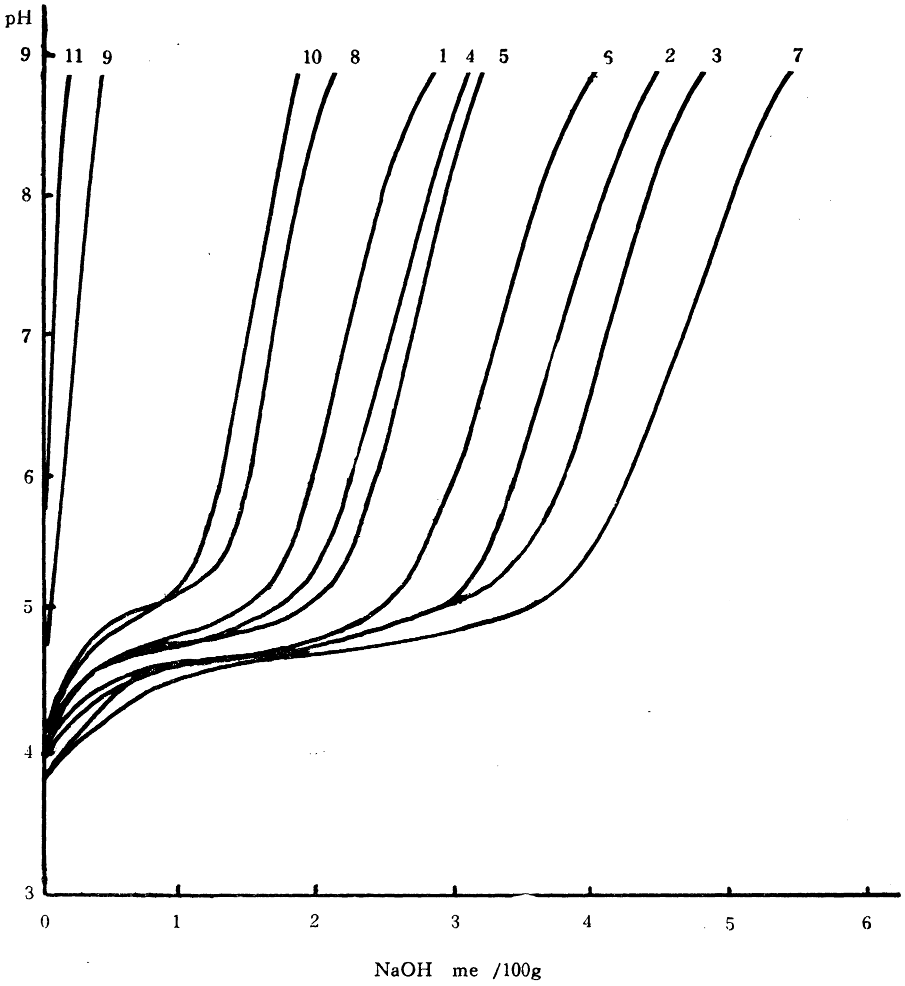

圖2. 供試園土壤之 N-KCl 浸出液滴定曲線

Fig. 2. Titration curve of N-KCl extractant of applied citrus orchard soils.

討　論

多年生果樹栽培結果，常會引起果園土壤的退化作用，而土壤的酸性化乃為退化作用中最主要的特徵。本省之柑橘栽培，由於果園管理作業上的諸多方便，與減少病蟲害之發生等原因，迄今仍多沿用裸露式耕耘法。然本省多雨且雨量集中，坡地橘園採用裸露式耕耘，易促成土壤中鹽基類的溶脫與

不平衡的養分吸收。同時，生理酸性化學肥料的連續多量施用，會使土壤中聚積可溶性酸，更加速鹽基的溶脫。此種土壤中鹽基溶脫與酸性物質聚積的循環作用，終會導致土壤的强酸性化。

自從大工原氏爲速測酸性土壤的石灰需要量，以中性的 KCl 浸出液測定置換酸度，而發現鋁離子爲置換酸度中最主要的構成成分以來，已知 Al^{3+} 或其重合體〔$Al(H_2O)_6$〕$^{3+}$ 經加水分解產生氫離子，爲一般酸性土壤中最重要的酸性來源。據 Coleman 等[6]，酸性土壤中交換性鈣、鎂及鋁約佔 P-charge 置換基的 90% 以上，弱酸性土壤以交換性鈣、鎂佔較大比率，强酸性土壤則以交換性鋁佔多。吉田[4]即由鋁水溶液的滴定曲線形狀指出，酸性土壤中鋁離子以 3 價的單體Al^{3+}與鹽基性鋁的重合體兩種形態存在，而隨土壤 pH 的降低，Al^{3+} 就逐漸增加，以至 pH 4 以下時，Al^{3+} 會變成主要的鋁離子。吉田[4]又指出，在鋁離子滴定曲線中，其緩衝域的中心變曲點在於 pH 5 附近，故其酸性强度大約爲 pKa 5，即相當於醋酸（pKa 4.7）的酸性强度。Yuan[11]亦由 $AlCl_3$ 水溶液的滴定曲線指出，Al^{3+} 的緩衝能在 pH 4.3 附近，而將滴定至 pH 5.4 就可完成其中和反應。

在本省柑橘園土壤的酸度要因物質中，與土壤 pH 最有關連者乃爲置換酸度。然而置換酸度的79%至 86% 皆係鋁離子。因此，酸性柑園土壤的酸性來源，主要爲交換性鋁離子，經加水分解後產生氫離子。另就 N-KCl 浸出液檢定交換性鐵結果，供試土壤僅含有極少量或殆無交換性鐵的存在，故柑園土壤中交換性鐵並不構成酸性來源。在置換酸度測定中，將 NaF 添加於 N-KCl 浸出液，則依下列反應式 $AlCl_3+6\,NaF \rightarrow Na_3AlF_6\downarrow +3\,NaCl$ 可生成 Na_3AlF_6 的沈澱，但浸出液就仍示酸性反應，可知置換酸度中尚含有 NaOH 可滴定的其它酸性物質，其含量約佔置換酸度的 14%至 21%。本省一般柑園土壤的有機質含量，多數介於 1 %與 3.5%間，且 C/N 亦低，其土壤中應很少含有游離有機酸。試就供試土壤的水浸出液測定 NO_3^-, SO_4^{--} 及 PO_4^{---}（可能包含 polyhosphate）含量結果，均含有相當量的 NO_3^- 及 SO_4^{--}，顯示在强酸性柑園土壤中產生硫酸、硝酸等游離酸的可能性。由以上結果可知，本省柑橘園土壤，經過長時間的裸露耕耘與生理酸性肥料的連續多量施用，土壤中產生硫酸、硝鹽等游離酸。此等游離酸中的氫離子，則如 Mitra 等[7]所指出，頗不安定，會破壞粘土而產生鋁離子或鹽基性鋁離子，代替以置換基中的鹽基類。此可由極强酸性柑園土壤的交換性鋁飽度，多已達 40% 至 77%，做爲引證。土壤中游離酸的生成就可導致鋁離子的聚積與鹽基類的溶脫，促使柑園土壤逐漸趨於强酸性化。水和鋁離子〔$Al(H_2O)_6$〕$^{3+}$ 則以其弱酸與弱鹽基兩面性質緩衝土壤中產生的氫離子。本省柑橘園土壤的酸性化作用，大多數已進展到相當程度，其 pH 值已降至4.2與4.9之間，即鋁離子的緩衝域，而依各土壤中所生成的鋁離子 Al^{3+} 以及各形態鹽基性鋁離子的含量變化，呈現出 pH 4.2 至 4.9 之間的强酸性反應。

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Acid Source and Its Acidification of Citrus Orchard Soils of Taiwan[1]

Wen-Lian Huang[2]

Summary

Most of citrus orchard soils of Taiwan are characterized by its strong acid reaction. The strong acidity of soils is presumed partially responsible for the low productivity and short life of citrus trees. Eleven citrus orchards which were representatives of the major citrus producing areas were selected and they have been cultivated for more than 12 years. Soil samples taken from these orchards were examined for acid substances and their acidification. The soil pH readings of most of these orchards ranged from 4.3 to 4.9, showing very strong acid reaction. Tong-shieh orchard soil which has been cultivated for 47 years showed a pH reading of 3.7, which is extremely acid. The cultivation method which remains the ground uncovered and long continuous application of chemical fertilizers containing acid substances have resulted in the rapid leaching out of soil bases and the accumulation of aluminum ions. The saturation degrees of exchangeable aluminum in these orchard soils reached 40 to 77 per cent. Exchangeable aluminum content has a highly negative correlation with pH values ($r=-0.81^{**}$). The existence of a measurable amount of hydrogen ions in the exchange acidity indicates its importance in soil acidity. The titration curves of N-KCl extractant also showed a strong buffer action of aluminum ions between pH 4.2 and 5.2. The lower the pH, the stronger was the buffer action of the extractants. It is suggested that acid source of citrus orchard soils of Taiwan mainly results from the accumulation of aluminum ion and hydroxyl aluminiumions which produces hydrogen ion on hydrolysis. When the cumulative amount of aluminum ions reaches certain level as a result of long-term cultivation, they may exhibit strong acid reaction with pH readings between 4.2 and 5.2, which is the buffer action range of aluminum ion.

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1. Contribution No. 1083 from the Taiwan Agricultural Research Institute.
2. Soil Scientist. Department of Agricultural Chemistry, TARI, Taichung Hsien, Taiwan 431, R. O. C.

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水稻聯合收穫機用於收穫高粱之研究試驗[1]

顏欽崇　楊清祥[2]

摘要：本研究係以國產野興牌 YS 1300 型水稻聯合收穫機改良而成為高粱聯合收穫機，除可收穫高粱外，換下部分機件即可收穫水稻，反之亦然。本試驗機依據收穫高粱之試驗結果所顯示之缺點，分七個步驟改良完成。1.提高機頭扶起裝置動力傳動橫軸，並拆除前閘門橫板，以允許較高高粱穗通過。2.底部夾送鏈條與其夾導桿間之展開間隙加大，可讓較粗之株桿通過。3.增長可調傾斜橫向夾送鏈總成長度，以調整高粱穗脫粒之適當位置。4.改良可調傾斜橫向夾送鏈條與脫粒夾送鏈條間之轉接導桿，使株桿能順利進入脫粒夾送鏈。5.增置導穗板，便利高粱穗部之導入脫粒室。6.增加鼓風機迴轉數，提高風選能力。7.增加回送管旋轉葉片迴轉數，增強擲送回脫粒室能力，避免回送管阻塞。

本試驗機已達可推廣使用階段，收穫高粱之作業能量為每日0.8～1.5公頃(一日以8小時計算)，作業流量可達1,060 kgs/hr，場地工作效率為 78～82%，人工收穫高粱之費用每公頃約需 7,500元，用本機收穫所需費用每公頃約需5,500元，則每公頃約可節省2,000元，同時替代勞力20～25人工次 (man-day) 。

高粱與水稻同屬禾本科作物，為本省主要雜糧作物之一。除供釀酒原料外，並為飼料之用。本省種植面積約四千公頃，目前都以人工採收脫粒，非常辛苦，形成推行低產水田轉作之一大阻力。本所有鑒及此於69年度提出水稻聯合收穫機多用途計畫包括燕麥，高粱及亞麻等作物之收穫試驗，藉以解決農村勞力缺乏問題。到現在為止本省共有水稻聯合收穫機一萬六千多台，如能將這些水稻聯合收穫機之部分機構加以改良使達到兼收高粱之目的，則不失為高粱機械化收穫之捷徑，使高粱之栽培從整地至收穫，均有機械可資使用，而成為繼水稻之後另一種可完全以機械一貫化作業栽培之作物。

前此本省公私機構，雖曾做過類似之改良試驗，並舉辦觀摩會，惜因未達理想不能為農民所接受。本所研究之初曾先以日製井關牌 HD 1500 型水稻聯合收穫機為試驗機種進行高粱收穫改良試驗，結果相當不錯，為提高國產聯合收穫機之利用率，以降低投資生產成本故以此成果為藍本，從70年度始改以野興牌 YS 1300 型水稻聯合收穫機為試驗母機，進行改良迄71年 7 月亦在嘉義朴子鄉、太保鄉及臺南學甲鄉進行試驗觀摩甚獲農民之好評，肯定了推廣之價值。

材料與方法

一、試驗機具與材料：

1.國產野興牌 YS 1300 型水稻聯合收穫機一台。

2.改良用材料：鐵板、圓鐵、彈簧、鏈條、三角皮帶零件及附屬設備等。

1.臺灣省農業試驗所　研究報告1084號。

2.本所農機系主任、助理。臺灣省　臺中縣　霧峰鄉。

3.試驗材料：高粱。

4.測定儀器：碼錶、轉速計，捲皮尺、拉力計，土壤硬度計及應度測定儀等。

二、試驗方法：

1.經臺中五號高粱之種植，及高粱性狀之調查，高粱與水稻同屬禾本科植物，具耐旱之特性，一般都在新生地，鹽分地或缺水地區之旱田種植，高粱成熟期，植株高度差異變化很大，在同一品種，同一田區中均可發現 100 cm 左右之穗位差，此穗位差雖然很普遍，但數量並不多，約佔 1/50～1/80 之數，較整齊之穗位差平均在 45 cm 左右，株高約在 90～160 cm，株桿基部直徑約在 1.2～3.2 cm，穗頸部直徑 0.6～1.2 cm，千粒重 35～37.5 g 葉片寬大、葉肉較厚，含水率 72～80% 較水稻葉含水率高10～15%，高粱之脫粒性較水稻困難，採收時高粱每粒之抗脫力（拉脫）平均為 130 g，測定高粱含水率為31.6%，取穗平舖地面曝晒一天後，再測抗拉力，結果需要更大之拉力，才能脫粒，其平均抗脫力為 150 g，此時所測高粱含水率為 19%，再經一天之曝晒，含水率降至 12%時，高粱平均抗脫力為 160 g，由抗脫力試驗證明高粱脫粒，宜於割穗後立即脫粒為最佳，亦則脫粒用馬力最省。

從以上性狀基本調查結果，得知高粱與水稻類似及其差異點，供作改良水稻聯合收穫機兼收高粱之參考，（看表1）

表1.　高粱與水稻性狀比較表

Table 1. Sorghum & rice grow characteristic comparion

項目 Item	高粱 Sorghum	水稻 Rice
株高 cm Stalk height	90～160	90～115
株莖 cm Stem diameter	1.2～3.2	0.4～0.5
穗位差 cm Postiton difference between heads of grains	100	35
千粒重 g Wt per throusand grains	35～37.5	25～30
谷含水率 % water contained	20～25	18～25
桿含水率 % Stalk water contained	83～86	70～75
葉含水率 % Leaf water contained	72～80	62～66
倒伏性 Tendency to fall down	不易倒伏 Not easy	較易倒伏 Easy
拉脫力 g Thresh resistance per grain	120～200	0～140
葉型 Leaf type	葉寬大 Wide leaf	葉狹長 Long leaf

2.高粱成熟時以國產野興牌 YS 1300 型水稻聯合收穫機，未經改良即進行高粱收穫試驗，其作業程序如圖1.為分草扶起，剪切，輸送脫粒，株桿收集及落地，種粒篩選及分離，精選粒輸送包裝，未脫粒及混雜物經旋轉擲回器，送回脫粒室再一次脫粒，完成循環脫粒作業。在試驗程序中發現缺點，依據試驗結果，在不做重大修改前提下，將各缺點加以改良，使成為高粱聯合收穫機。

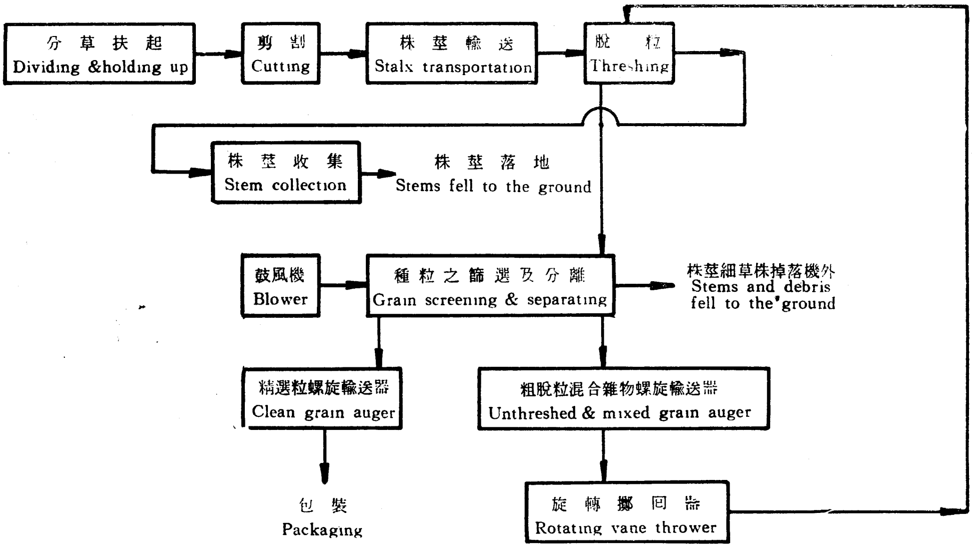


圖1. 高粱水稻聯合收穫機收穫程序圖
Fig. 1. Sorghum & rice combine flows sheet

三、試驗過程：本機在高粱收穫中順序探討各機構對收穫高粱時之實際情況如下：

1.切割試驗：以 YS 1300 型水稻聯合收穫機所使用之往復式切割刀，經實際切割高粱試驗結果顯示十分良好，株莖 1.2 cm～3.2 cm 都可順利切割，符合高粱收穫切割之要求。

2.株桿夾送系統：夾送鏈條包括：底部夾送鏈，可調傾斜橫向夾送鏈，脫粒夾送鏈，與集株桿夾送鏈等，其中除底部夾送鏈條與可傾斜橫向夾送鏈條外，其他皆無問題。原下部夾鏈與夾送導桿間，因夾株桿時所能開展之間隙最大僅 1.6 cm，亦即在收割高粱時，若遇株桿莖大於 1.6 cm者，均甚難順利夾送通過，而發生阻塞。可調節傾斜橫向夾送鏈之主要功用在將下部輸送鏈條轉交來之株桿，依據其高度適當調節夾送長度，轉送至脫粒夾送鏈者，此傾斜橫向夾送鏈總成原可調節之長度為 28 cm，加上深調時，脫粒夾送鏈之夾點至作物棵桿切割處之距離 25 cm 共計可調距離 53 cm，適合於水稻株桿之脫粒調整，而水稻株高最高限在 130 cm，顯然不適於調節割取高度在 160 cm 之高粱。

3.收穫頭前閘門橫板及扶起鏈動力傳動橫軸：收穫機頭前閘門橫板及傳動橫軸離地面 110 公分，而收穫機頭可藉油壓提高 38 cm，共計高度 148 cm，但在田間實際作業時，因高粱需培土作畦之關係，若土質稍較鬆軟，則易使履帶下陷入泥土中約 5～15 cm，故前閘門橫板對高粱之收割高度限制在 135cm 左右，但高粱之株高一般均高於此數，因此收割之高粱為橫板及橫軸所擋住，容易折穗及增加脫粒損失。

4.水稻用脫粒筒對高粱脫粒性能：為瞭解水稻脫粒室對高粱脫粒之性能，從田間割取高粱，其長度自穗頂到切割處 80 cm，送到實驗室做脫粒試驗，定脫粒筒速度為 480 RPM，將高粱桿直接送入脫粒夾送鏈，夾入脫粒室內脫粒，脫粒深度約 45 cm，分別測定未脫粒損失率，排塵口損失率以及精選送入袋中之高粱組織成分比率等試驗結果如下：

（1）高粱穗之脫粒率可達 100%，未脫粒等於零，可見 V 型脫粒齒對於高粱之脫粒性能甚優，唯高粱穗頭部有嚴重碎裂及小支梗脫粒之情形發生，致影響脫粒室負荷及排塵損失之增加。

（2）排塵口損失率測定為0.36%，情況非常理想。

（3）脫粒後經選別後裝入袋中之高粱成分為：完全脫粒之高粱66.6%，單粒高粱帶穎率18.8%，斷梗含二粒以上高粱6.9%，破損率 0.5%，夾雜物 7.2%，從袋內谷物整體看雖未達清潔之要求，但高粱破損率都很低，為本水稻脫粒筒用於高粱脫粒可取特性之一。

（4）爲求進一步了解此種脫粒筒 R. P. M. 與高粱脫粒性能之關係，在脫粒試驗時，取下承網，停止振選系統，在脫粒筒下放置盛箱，直接收集經脫粒筒脫粒後之所有產物，分析結果如表2.，並參看圖2。

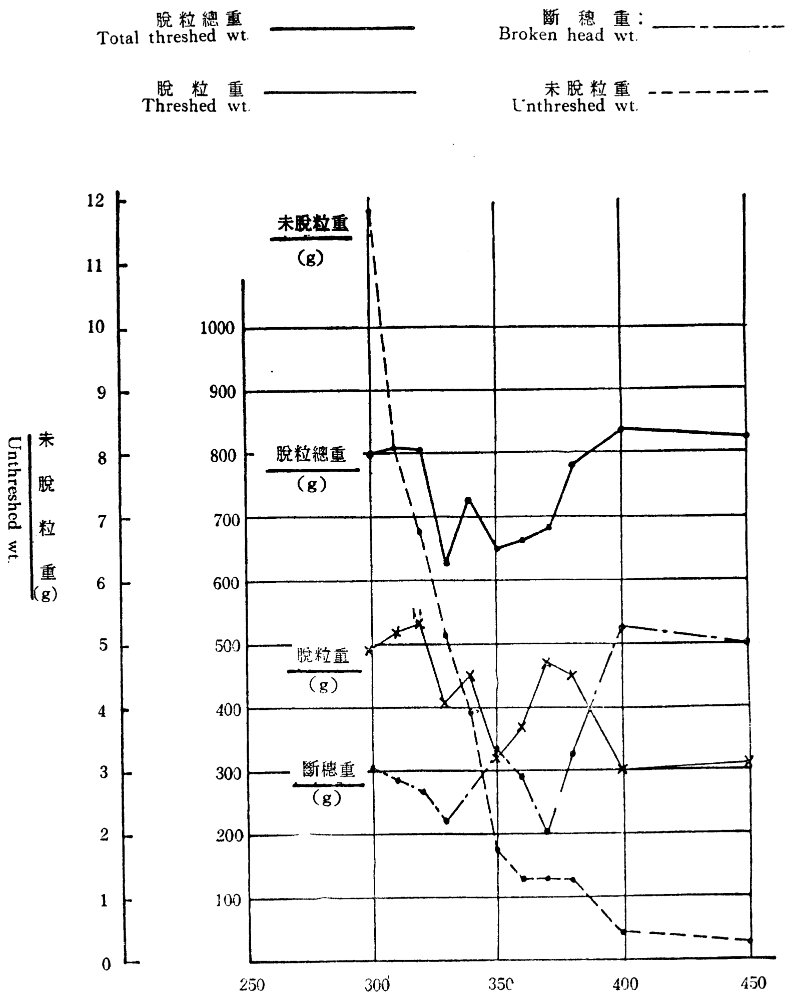


圖2. 脫粒筒 R. P. M.

Fig. 2. Threshing drum

比較表中數值得知脫粒筒 R. P. M. 與未脫粒量成反比例，則轉速愈慢，未脫粒愈多，從表上知 340 R. P. M. 以下時，未脫粒即呈現非正常之顯著增加，在 400R. P. M. 時觀察排桿、穗頸基部破裂及小支脫離情形呈嚴重現象，致大量斷穗進入脫粒室內，在 360 R. P. M. 時穗莖即有破碎現象，但尚未斷離株桿，故從減少斷穗及減輕脫粒室處理負荷上考慮，較理想之高粱脫粒轉速應在 360 ~380 R. P. M. 之間。

5.選別系統：承網網目爲 1.5 cm 正方形孔，原搖振篩網均適用於高粱之選別，唯精選穀中含雜物較多。

表2. 脫粒筒 R. P. M. 與脫粒、斷穗、未脫粒之關係表

Table 2. Relation among thresher R. P. M. with threshed grains, broken heads and unthreshed grains.

R. P. M.	脫粒總重 (g) Total wt. of plants threshing	脫粒重 (g) Wt. of threshed grains	%	斷穗 (g) Broken heads	%	未脫粒重 (g) Wt. of unthreshed grains
450	823	318	38.6	505	61.4	0.3
400	838	305	36.3	533	63.7	0.45
380	782	455	58.2	327	41.8	1.25
370	680	475	69.8	205	30.2	1.30
360	663	366	55.2	297	44.8	1.30
350	651	321	49.9	330	50.7	1.78
340	728	455	62.5	273	7.5 3	4.0
330	630	410	65.1	220	34.9	5.16
320	805	535	66.5	270	33.5	6.6
310	808	520	64.4	288	35.6	8.1
300	800	495	62.3	305	37.7	11.84

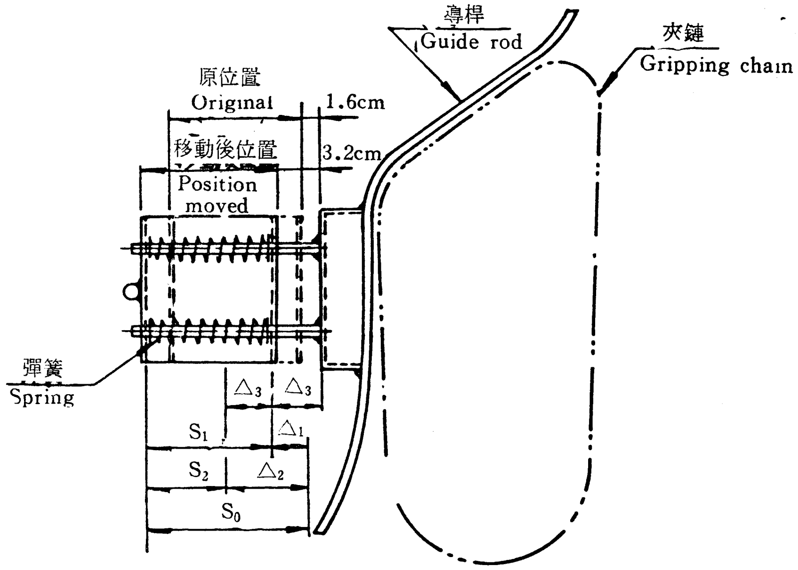


圖3. 夾鏈導桿支架修改圖

Fig. 3. Gripping chain quide rod support improved

6.二號螺旋輸送器之回送管：本水稻聯合收穫機之回送管設計較小，故以旋轉葉片將進入二號螺旋輸送器之高粱混合雜物擲回脫粒筒時易發生堵塞。

綜合以上試驗共有七項較為明顯之缺點：

（1）底部夾送導桿與夾送鏈之間若株桿大過 1.6 cm 時即發生阻塞之現象。

（2）扶起鏈動力傳動橫軸及閘門橫板阻礙高粱穗順利通過，易使穗部折彎或折斷。

（3）高粱穗進入脫粒室過深，易形成斷穗增多，且將穗桿部分一起打落，使篩選負荷增加。

（4）割取之高粱穗粗硬，進入脫粒室不順暢。

（5）在可調傾斜橫向夾送鏈與脫粒夾送鏈之轉接不順，致常有落桿發生，阻礙作業之連續性。

（6）經精選包裝之高粱粒不够清潔雜物多。

（7）旋轉擲回器，回送管常有堵塞現象。

四、收穫機部分機構之改良及其作業狀況：

（一）以水稻聯合收穫機改良成高粱水稻兩用聯合收穫機，因收穫高粱及水稻兩種作物之流程相同，參看圖一，故改良本機應以盡量不修改原機構爲原則，並能達到一機兩用之目的，動力傳送系統亦相同（看圖6）。

（二）根據原水稻聯合收穫機試收高粱之七項缺點加以改良。

1.底部夾送導桿與夾送鏈條間開展距離之增大，看圖3，照片3，原夾送鏈與導桿托架間開展距離最大僅 1.6 cm，亦即作物株桿徑超過此數，即形成株桿壓擠而難於順利夾送通過，產生阻礙作業之進行。一般高粱株桿徑可達 3.2 cm，爲使株桿徑超過 1.6 cm者亦能順利通過，將托架向後移動 1.6 cm 並更換彈簧即可。則 $\triangle=1.6+1.6=3.2$ (cm)

2.彈簧之壓力 P 及變形△之求法。

由公式 $\triangle=\dfrac{8PD^3n}{E_s d^4 K}$ ………… (1)

$P=\dfrac{\triangle E_s d^4 K}{8D^3 n}$ ……………… (2)

式中：P＝爲彈簧壓力

△：爲彈簧受 P壓力後之變形

D＝爲彈簧平均直徑

n＝彈簧有效圈數

d＝彈簧鋼條直徑

E_s＝剪彈性係數

K＝應力因素

3.彈簧長度之計算（如圖3）

S_0＝未受壓力時之長度

S_1＝彈簧變形$\triangle_1$時之長度

S_2＝彈簧變形$\triangle_2$時之長度

$S_0=S_1+\triangle_1=S_2+\triangle_2$

$S_2\geqq(n+1\frac{1}{2})d$

（三）提高扶起鏈條動力傳動橫軸及拆閘門橫板：

看圖4、照片1，一般之水稻聯合收穫機設計割取株高之最大限度約爲130cm，因此把它用以割取160 cm左右高度之高粱，必須將閘門橫板拆除，並提高動力傳動橫軸 36 cm，才能使高粱穗順利通過前門，避免高粱

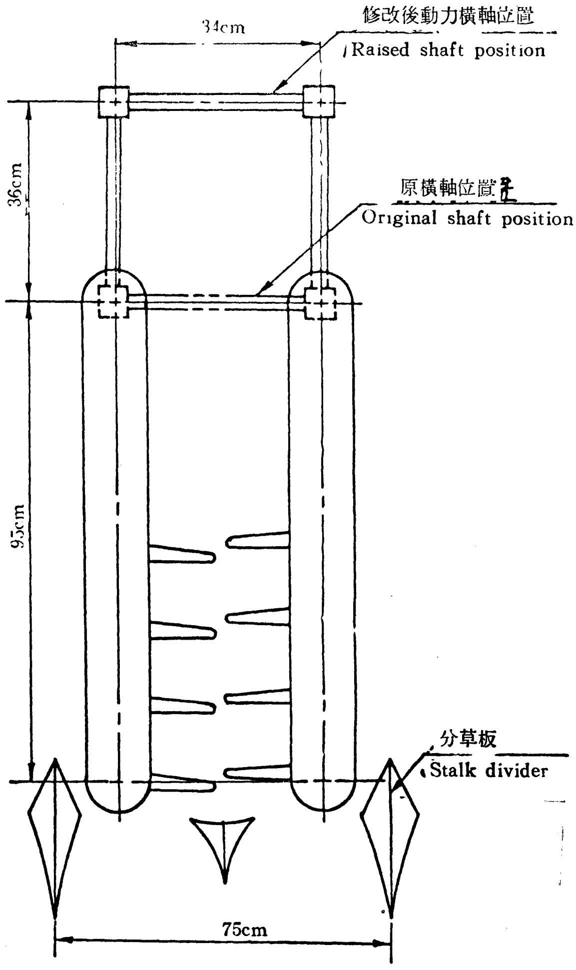


圖4. 扶起動力橫軸修改高度位置圖
（水稻聯合收穫機用於收穫高粱之扶起裝置）
Fig. 4. Holding-up transverse shaft

穗被擋折彎或折斷而致之損失缺點。

（四）加長可調傾斜橫向夾送鏈總成：

本橫向夾送鏈之功用在轉接自底部夾送鏈送來之株桿，調整適當之脫粒深度後轉送至脫粒夾送鏈者，因用於調整水稻株桿之長度不够，故將橫向夾送鏈增長 25 cm，以配合夾持較高高粱株桿之需要，以獲得最佳脫粒深度 40 cm，此即自穗頂至脫粒夾送鏈中心之距離。參看圖 5 、及照片 4 。

（五）加裝高粱穗導入板，原有導穗板較低適用於水稻脫粒，提高動力橫軸後必須加裝導穗板以補所留空間，才能將高粱穗順利導入脫粒，看照片 2 。

（六）改良脫粒夾送鏈導之入桿看圖 5 ，照片 4 ，脫粒夾送鏈之導入桿，須根據高粱株桿輸送導入之情況改良，使其能順利將來自可調傾斜橫向夾送鏈之株桿導入脫粒夾送鏈內夾住，避免滑落或阻塞之發生。

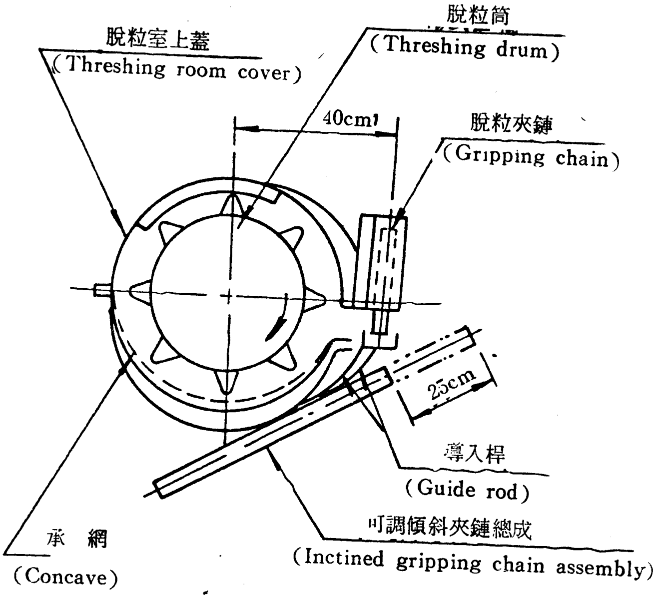


圖 5. 可調傾斜夾鏈位置圖

Fig. 5. (Adjustable inclined gripping chain)

（高粱聯合收穫機）

（七）增加鼓風機迴轉數看圖 6 ，鼓風機速度，測定爲 980 R. P. M. 因風選情況不佳，精選穀粒不够清潔，因此將鼓風速度增加 120R. P. M. ，迴轉數增加後其選別率可提高 10% ，亦即鼓風機速度在 980 R. P. M. 時，選別率爲 86% ，提高爲 1,100 R. P. M. 後其選別率可達96 %，鼓風機速度雖只增加1.12倍，$\left(RPM_2 = RPM_1\frac{1,100}{980} \doteqdot 1.12\,RPM_1\right)$ 但所需馬力卻增加 1.4 倍$\left[\frac{HP_2}{HP_1} = \left(\frac{RPM_2}{RPM_1}\right)^3 = \left(\frac{1,100}{980}\right)^3 = 1.4\right]$風量亦增加1.12倍 $\left[V_2 = V_1 \times \left(\frac{1,100}{980}\right) \doteqdot 1.12V_1\right]$。空氣壓力可增加1.26倍$\left[Ps_1 = Ps_1 \times \left(\frac{1,100}{980}\right)^2 \doteqdot 1.26\,Ps_1\right]$。

（八）增加擲回旋轉葉片之速度（看圖 6 、⑤） 回送管擲回旋轉葉片之速度原爲 1,150 R. P. M. 提高 120R. P. M. 後爲 1,270 R. P. M. 可增加葉片擲回數量，避免回送管之阻塞，葉片速度增加 1.1 倍$\left(\frac{RPM_2}{RPM_3} = \frac{1,270}{1,150} \doteqdot 1,104\right)$馬力需增加1.346倍$\left[\frac{HP_2}{HP_1} = (1.1)^3 \doteqdot 1.346\right]$

結 果 及 討 論

一、機器結構改良部分：

改良水稻聯合收穫機，使其成爲高粱聯合收穫機，需要更換或修改之機構爲：

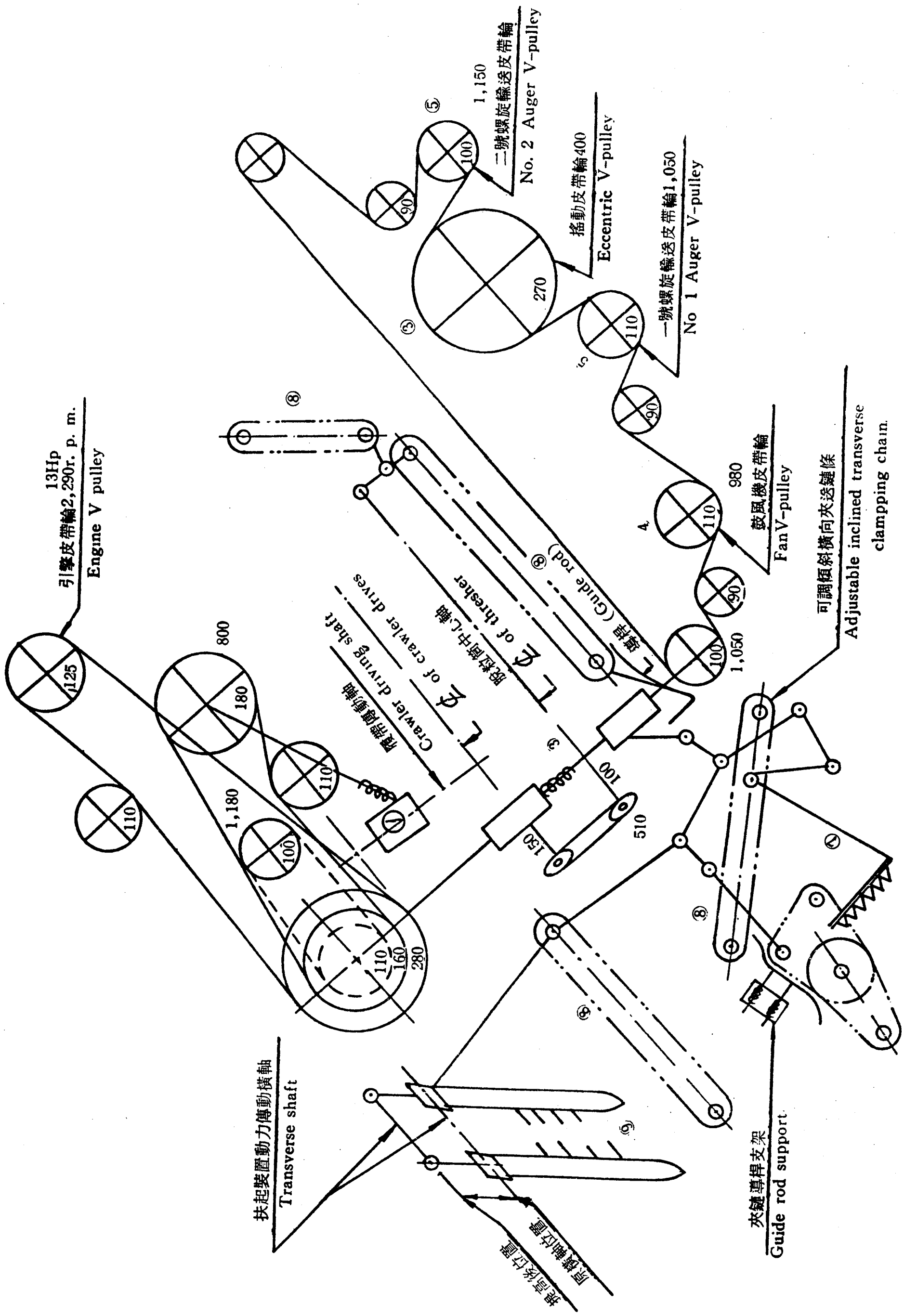
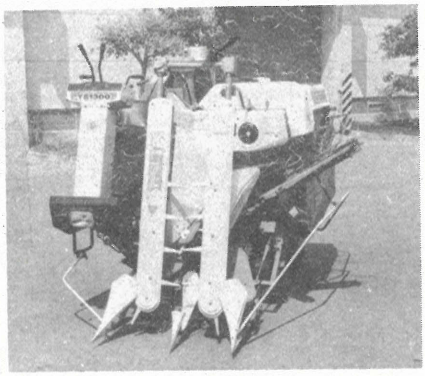


圖6. 高粱水稻聯合收穫機動力傳遞系統模擬展示圖

Fig. 6. Power transmitting schematic diagram of surghum & rice combine



照片1. 高粱水稻兩用聯合收穫機
前視圖箭頭指示動力傳動橫軸提高
36 cm 後之位置。

照片2. 側視圖箭頭指示高粱穗導入板

照片3. 底部夾送鏈導桿支架及彈簧。

照片4. 可調傾斜橫向夾送鏈總成及脫粒夾送鏈導入桿。

1.重新設計底部夾送導桿支架及壓力彈簧以配合粗細株桿之夾送，彈簧係根據原機之支架彈簧壓力而設計，故展開度雖由 1.6 cm 變大為 3.2 cm ，但其夾持總壓力相同，因此可兼用於夾送較粗之高粱株桿及水稻株桿，因為設計之彈簧初壓及終壓相同故也。亦即展開寬度雖不同，而其架送壓力却在一定範圍內變化，不影響兩者之夾送作業。

2.拆除閘門橫板及將扶起鏈動力傳動橫軸之支架重新設計提高 36 cm 以適合高粱穗之夾送通過。收穫高粱穗之高度可達 165 cm 提高之高度不必限制在 36 cm，可酌予降低或提高以適應各地區高粱生長高度之差異。

3.動力傳動橫軸提高後須加裝導穗板以彌補空格以利穗部之導入脫粒室。導穗板之加裝乃以補足因提高橫軸及所增加空間，使高粱穗能順勢進入脫粒室，增加導穗板不影響水稻之收穫作業。

4.可調傾斜橫向夾送鏈加長 25 cm，以調整脫粒最佳長度，因為脫粒位置影響脫粒效率甚大，根據試驗最佳脫粒長度為自穗頂至脫粒夾送鏈之距離為 40 cm ，此鏈加長 25 cm 之後已可正確調整高粱穗進入脫粒室最佳脫粒之位置。

5.脫粒夾送鏈導入桿之改良，使高粱株桿能順利夾入脫粒夾送鏈中，株桿導入桿之曲線務使株桿脫離橫向夾送鏈後能順利導入脫粒夾送鏈為改良之主要目的。導桿之曲線無一定之形狀，可依據作物性質適當製作。

6.換置鼓風機及二號回送螺旋輸送機之皮帶輪，各提高 120 R. P. M. 藉以提高風選去蕪能力及擲回脫粒筒能力以免除回送管之堵塞，鼓風機轉速增加後，風量之增加與轉數之增加成正比，風壓增加與轉速比之平方成正比，故速度增加後選別風壓增加0.25倍，有助於選別能力，但所需之馬力則與轉速比之 3 次方成正比，亦即風量只增加0.12倍，但馬力却需 0.4 倍。選別能力增加10%，對獲得較為清潔之高粱甚有幫助。回送管擲回葉片之回轉數增加情況與上述鼓風機相同，因有風扇之作用，故風量增加 0.104 倍，風壓增加 0.22 倍，所需馬力則增加 0.346 倍，故提高轉速有助於疏通回送管之作用，自把回送管擲回葉片轉數提高後未見再有堵塞情形發生。

二、機械性能試驗：

經改良完成之試驗機除在本所田間試驗外於71年 7 月運往嘉義縣朴子鎮做性能測定，其試驗結果如表 3，測試高粱品種為臺中 5 號，本機合計總收割面積已達5 ha以上，本表只測試代表性收割面積。

1.作業能量：本試驗機每次收割一行，若穗位較整齊時，可使用行車速度第六擋（0.89 m/s）收割，每小時可收穫 0.155 ha ，比水稻收穫為快速。

2.作業清潔度：在高粱生育正常情況下收穫，經由精選揚穀口裝袋之高粱，完全脫粒率可達87.2%，如果單粒帶穎被認可存在，則本機選別率可達 97.5%。

3.損失率測定：本試驗僅測定田間掉粒損失及排塵損失，前者為0.5～0.63%，後者為0.9～1.77%合計總損失率為1.44%～2.23%，未超出中央標準局暫訂水稻聯合收穫機機性能檢驗損失率不得超過 3 %之標準，應可為一般農民所接受。

4.脫粒碎米率保持在 0.5%以下 ，證明直接可用水稻聯合收穫機脫粒筒脫粒 ，不致產生碎粒。

三、機械收穫與人工收穫效益之比較：

本省七十一年度高粱種植面積約 4,000 公頃，假設收穫期間需在 30 天內完成，如全部以機械收穫，以每台聯合收穫機每年可收穫 30 公頃計算，約需高粱聯合收穫機 133 台。

1.用人工收穫，每一公頃人工費

採收：5,000 元。

晒乾脫粒篩選：2,500元。

合計：7,500元。

2.用機械收穫：每一公頃機械代收費 5,500 元（包括機械租金、油料及工資在內）。

3.以機械收穫比人工收穫每一公頃可節省費用：

表3. 高粱聯合收穫機性能測定表

Table 3. Performance test of sorghum combine

	項目	抽試次數	1	2	3	4
1	日期	地點	71.7.9 朴子鎭	71.7.10 朴子鎭	71.7.11 朴子鎭	71.712 朴子鎭
2	品種	成熟度	臺中5號	臺中5號	臺中5號	臺中5號
3	千粒重 g	行距 cm	33 60	34.8 63.3	5.5 62.6	35.0 62.7
4	株高 cm	最高 最低 平均	168 120 150	161 90 140	160 85 150	164 70 145
5	水分率 %	谷 桿 葉	20.2 85.8 78.2	22.1 83.6 80.8	25.6 83.7 79.5	23.1 85.9 72.3
6	每10公畝高粱產量	kg	553.9	467.1	542.6	456.3
7	田面掉粒損失率	%	0.63	0.49	0.45	0.57
8	排塵口損失率	%	1.6	0.95	1.77	1.59
9	穀粒總損失率	%	2.23	1.44	2.22	2.16
10	碎米率	%	0.46	0.04	0.29	0.24
11	折算每小時高粱流量	kg	756	558	1,060	916
12	每10公畝草秣排出量	kg	150	82.9	120.5	111.6
13	嚴算每小時排桿量	kg	1,872	1,475	2,250	2,160
14	行車造率	m/s	0.67	0.56	0.89	0.88
15	機割時間	min	74	71	104	135
16	機割面積	m^2	1,399.9	1,251	2,690	3,604
17	每10公畝機割所需時間	min	52.9	56.8	38.7	37.5
18	每小時機割面積	m^2	1,135.1	1,057.2	1,551.9	1,602
19	機器實際工作量		11.4	10.6	15.5	16.0
	機器有效工作量	a/hr	14.5	12.8	19.9	19.9
20	田間有效工作效率	%	78.6	82.3	77.9	80.4
21	脫谷成分分析 完全脫粒率	%	87.2	84.3	86.3	76.1
	單粒帶穎率	%	10.3	12.6	10.4	20.1
	雙粒以上帶穎率	%	0	1.2	1.8	2.1
	雜物率	%	2.5	1.9	1.5	1.9
	備	註	5擋前進造度	4擋前進造度	五、六擋混合使用	五、六擋混合使用

7,500元－5,500元＝2,000元。

4. 若4,000公頃全部以機械收穫當可節省4,000×2,000＝8,000,000元。

四、採用高粱聯合收穫機以代替人工，假定機械每天收穫1公頃，則每天可節省人力約 20～25 人工次，每年可節省 4,000 ha×22.5 /ha＝90,000＝90,000 人工（man-day）。

建　議

1. 研究國產水稻聯合收穫機之多用途化，應選擇使用最多之機種爲首先考慮之條件，故本所選擇國產野興牌 YS 1300 型機爲試驗改良用母機。已改良完成之高粱水稻聯合收穫機，其有關改良機構之設計與製造已達商業化階段。且已收穫高粱 5 公頃以上，作業性能甚佳，故本機型收穫機可直接推廣使用。

2. 若以其他廠牌之水稻聯合收穫機修改，因每一種廠牌之收穫機構造稍有不同。修改方法亦有所差異，須依據本所研究之修改要點與方法，比照改良試驗完成之。

3. 所謂高粱水稻聯合收穫機，即是以收穫高粱爲主之聯合收穫機，機前應有較高之閘門，並附送較短「可調橫向夾送鏈總成」之聯合收穫機。

4. 一般而論，高粱之最佳脫粒轉數在 360～380 R. P. M 之間，而水稻聯合收穫機脫粒筒之轉速却在 480～520 R. P. M. ，目前所完成之高粱聯合收穫機仍以水稻脫粒筒之迴轉數收穫脫粒，情況尚佳。若能設計脫粒筒變速裝置，對選擇高粱之最佳脫粒速度或有所助益。

5. 從改善地力和增加收益上考慮，如能在間作種植高粱以代替田菁或太陽麻等綠肥作物，每公頃可多收穫約 5 公噸之高粱外，又可生產約 20 公噸之綠肥，一舉兩得。

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Modification and Improvement of Rice Combine into Sorghum Combine[1]

C. C. Yen, C. H. Yang[2]

Summary

An attempt was made in 1980 to modiyy and improve the locally made rice combine for harvesting sorghum grain. This Yeh-hsing YS 1300 rice combine has been modified or improved in seven steps to attain the aim, in accordance with the demerits exposed by the original combine which has been used to harvest sorghum.

The modified or improved components are : 1. Raise the power transmission transverse shaft 36 cm higher than the original position, and the front transverse gate plate was removed, so that it will alow the passing of sorghum heads. 2. Widen the open gap between the bottom gripping chain and guide rod to permit the passing of stalks, these stem diameters are larger than 1.6 cm. 3. Elongate the inclined adjustable transverse gripping chain assembly for 25 cm, so it can be used to adjust he proper length of the stalk of sorghum head entering the thresher. 4. Improve the guide rod between the inclined adjustable transverse gripping chain and threshed gripping chain, this will alow the stalks to enter the threshed gripping chain easier. 5. Add guide plates to the blank side of the combine caused by lifting the transverse shaft support, for guiding sorghum heads into the threshing room. 6. Increase the fan speed to increase the blowing ability of dirts. 7. Increase the speed of No. 2 auger with throwing back vanes in order to accelerate the ability of throwing material back to the threshing room.

This modiffied machine has reached the stage for commercially available at the present time, and has the abilityof sorghum harvesting capacity of 0.8 to 1.5 ha/day, grain flow capacity: 1,060kgs/ha, field efficiency : 78% to 82%. The sorghum harvest cost by human labor is N. T. $ 7,500/ha, and by this machine requires N. T. $5,500/ha, therefore it will save N. T. $ 2,000/ha, also it will take place the human laber labor of 20 to 25 man-days.

1. Contribution No. 1084 from Taiwan Agricultural Research Institue.

2. Senion Engineer and Research Assistant, Department of Agricultural Machinery TARI, Wufeng, Taichung, Taiwan 431, R. O. C.

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CONTENTS

Studies on the Reaction of Rice Varieties and Selections to Blast Disease ······ Lung-Che Chen······1

Improvement of Grain Quality in Rice II. Genetical Studies on Gel Consistency and Amylose Content ······ Yih-Chuan Kuo and Sung-Ching Hsieh······14

Studies on Shoot Tip Culture of Asparagus ······ Pen-Chih Lai, Liang-Jwu Chen, Meau-Meau Hsu and Hsin-Sheng Tsay······23

Axillary Panicle Induction in Mango (*Mangifera indica* L.) ······ Zen-Hong Shu······32

Variation in Fruit Characters between Normal-and Shrivelled-Seed Lychee Varieties ······ Chung-ruey Yen······39

Seasonal Variation Affecting Sex Expression of Coba (*Zizania latifolia* Turcz.) ······ Tsung-Dao Liou······50

Physiological Races of *Phakopsora pachyrhizi* in Taiwan···C. C. Yeh······69

The Infestation and Control of Bulb Mite (*Rhizoglyphus robini*) on Glandiolus ······ Chin-ling Wang······75

Acid Source and its Acidification of Citrus Orchard Soils of Taiwan ······ Wen-Lian Huang······83

Modification and Improvement of Rice Combine into Sorghum Combine ······ C. C. Yen, C. H. Yang······92

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